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CAPITAL AND OPERATING COSTS OF POLLUTION CONTROL EQUIPMENT MODULES

VOLUME II, DATA MANUAL

ICARUS CORP.

PREPARED FOR
ENVIRONMENTAL PROTECTION AGENCY

JULY 1973

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This Data Manual presents, in convenient graphical and tabular form, cost information for installed equipment item modules on separate data sheets. Each data sheet conforms to a uniform style providing information on the specific item and adjustments to atypical installation, construction, or design. The methodology used in developing this data and the techniques suggested for its use are described in detail in the companion User Guide. (See also W74-00307)(EPA)

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CAPITAL AND OPERATING COSTS OF POLLUTION CONTROL EQUIPMENT MODULES

Volume II

Data Manual

by

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Contract No. 68-01-0717
Project 21AQJ
Program Element 1B1030

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EPA Review Notice

This report has been reviewed by the Environmental Protection Agency and approved for publication. Approval does not signify that the contents necessarily reflect the views and policies of the Environmental Protection Agency, nor does mention of trade names or commercial products constitute endorsement or recommendation for use.

ABSTRACT

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SECTION I

CONCLUSIONS

1. The manual, CAPITAL AND OPERATING COSTS OF POLLUTION CONTROL EQUIPMENT MODULES (hereafter called ENVIRONMENTAL PROTECTION COST MANUAL), comprising this DATA MANUAL and companion USER GUIDE enables the user not expertly skilled in the particular technical field of cost engineering/process economics to prepare reasonable conceptual cost estimates for proposed environmental protection flow processing facilities. The easily used graphical and tabular format used for the presentation of data enable the user to rapidly evaluate alternative cost/process decisions for proposed environmental protection flow processing facilities.

2. Using the data in this DATA MANUAL and methods presented in the companion USER GUIDE, estimates of costs within 10 percent of actual constructed facility costs were obtained.

SECTION II

RECOMMENDATIONS

Based upon the results obtained in preparing this ENVIRONMENTAL PROTECTION COST MANUAL, it is recommended that the following action be taken by the Environmental Protection Agency:

- The technique of preparing comprehensive cost engineering data using a computerized detailed estimating system for this ENVIRONMENTAL PROTECTION COST MANUAL as applied to the installed equipment item module costs should be extended into the environmental protection process area. This ENVIRONMENTAL PROTECTION COST MANUAL has directed its efforts primarily toward the development of comprehensive cost engineering data on individual installed equipment item module costs which can be cumulatively developed into a proposed environmental protection flow processing facility cost. This same technique can be applied in developing overall process costs as a function of effluent guideline, regional location, etc.

- A procedure should be implemented so that the data in the DATA MANUAL is updated on a bi-annual basis. The cost engineering relationships in the DATA MANUAL are based upon 1972 technology. Technology in the construction industry is rapidly changing and it is recommended that these changes be tracked by bi-annual updates to the DATA MANUAL.

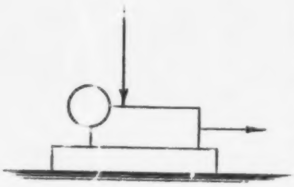
- Training courses in the utilization of the cost engineering information and methods presented in this MANUAL should be implemented and offered to technical personnel evaluating this type of information at the regional and headquarters level.

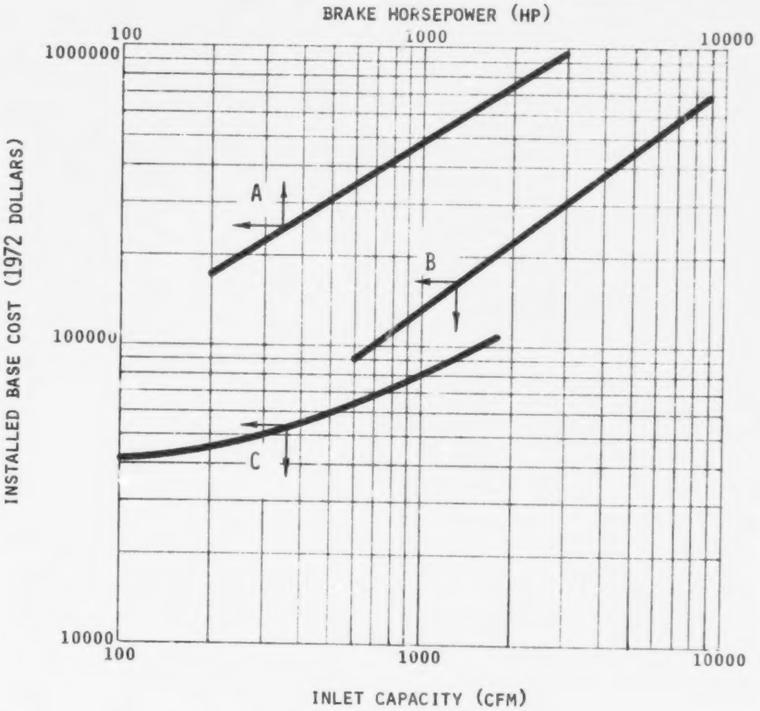
- The DATA MANUAL should be expanded to include additional installed equipment item module costs representing the new pollution control technology developed during the course of the development of the DATA MANUAL but not considered in the initial contract.

SECTION III
INDIVIDUAL DATA SHEETS

AIR COMPRESSOR

AIR COMPRESSOR





DESIGN ADJUSTMENT

Type	Curve	F_D	Capacity Range	Pressure Rating (PSIG)
One Stage Single Reciprocating	C	1.000	100-1800 CFM	150
Two Stage Single Reciprocating	C	1.561	100-1800 CFM	500
Three Stage Single Reciprocating	C	3.440	100-1800 CFM	2500
Two Stage Duplex Reciprocating	B	1.000	600-9000 CFM	125
Motor Driven Centrifugal	A	1.000	200-3000 BHP	---
Turbine Driven Centrifugal	A	0.870	200-3000 BHP	---
Gas Engine Driven Reciprocating	A	1.190	200-3000 BHP	---

REGIONAL ADJUSTMENT

Region	F_R
1	1.000
2	1.053
3	0.070
4	1.029
5	1.081
6	1.026
7	1.047
8	1.029
9	1.055
10	1.024

Installed air compressor cost includes purchased cost of air compressor, base plate, coupling, driver, cooler, handling and setting, piping, concrete, steel, instrumentation, electrical, insulation, paint, and indirect costs (prime contractor engineering and construction overhead).

INSTALLED AIR COMPRESSOR COST,$ = (INSTALLED BASE COST) $(F_D)(F_R)$

ANNUAL MAINTENANCE

Annual maintenance will vary from 0.91 to 1.57 percent of installed air compressor cost.

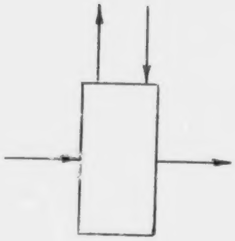
OPERATION COST

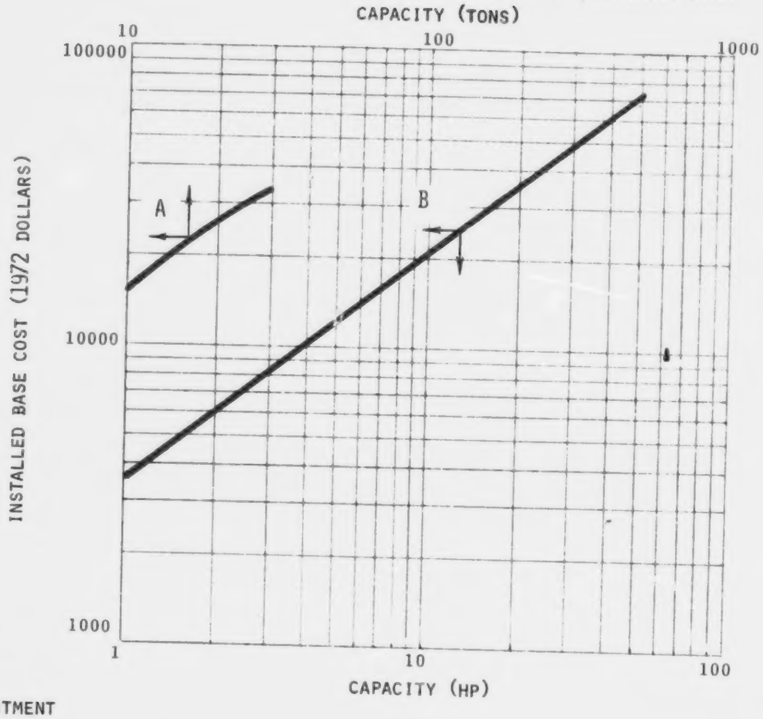
The air compressor will require between 0.03 and 0.039 operators per shift.

PROBABLE ANNUAL DEPRECIATION RATE

INDUSTRY GROUP	DEPRECIATION RATE (percent)	EXPECTED LIFETIME (years)
Heavy Chemical	0.05 - 0.091	11-20
Oil and Gas Refining	0.063-0.071	14-16
Resins and Polymers	0.071-0.111	9-14
Food and Beverage	0.056-0.091	11-18
Pulp and Paper	0.063-0.100	10-16
Mining	0.063-0.100	10-18

AIR CONDITIONING UNIT





DESIGN ADJUSTMENT

Type	Curve	F_D
Roof Mounted	A	0.00
Air Conditioning System	B	0.00

REGIONAL ADJUSTMENT

Region	F_R
1	1.000
2	1.102
3	0.989
4	1.054
5	1.097
6	1.039
7	1.084
8	1.050
9	1.079
10	1.052

OTHER COST DATA

Type	Installed Base Cost (1972 Dollars)
Floor Mounted	815.00
Window Vented	1220.00

Installed air conditioning unit cost includes purchased cost of air conditioning unit, handling and setting, piping and ductwork, concrete, steel, instrumentation, electrical, insulation, paint, and indirect costs (prime contractor engineering and construction overhead).

INSTALLED AIR CONDITIONING UNIT COST,\$ = (INSTALLED BASE COST) $(F_D + F_R)$

ANNUAL MAINTENANCE

Annual maintenance will be approximately 1.5 percent of installed air conditioning unit cost.

OPERATION COST

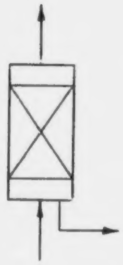
Air conditioning units require no operator attention.

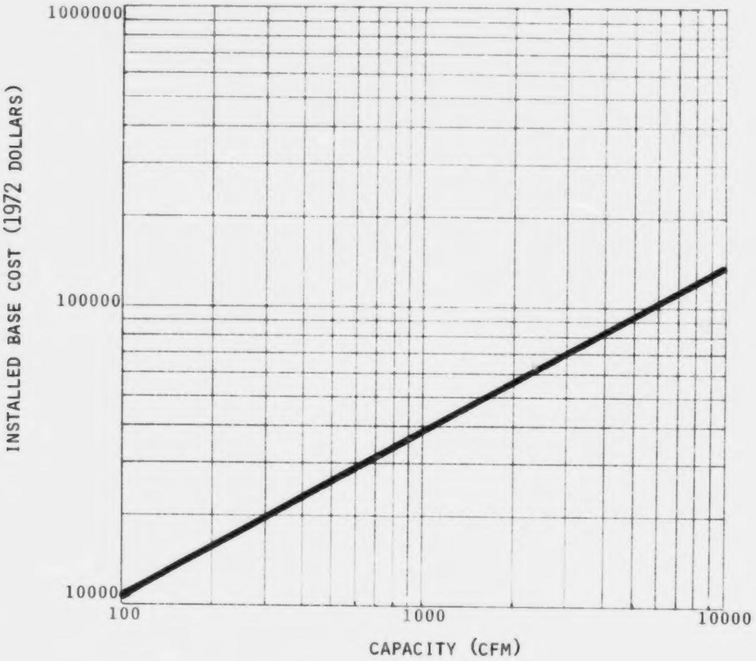
PROBABLE ANNUAL DEPRECIATION RATE

INDUSTRY GROUP	DEPRECIATION RATE (percent)	EXPECTED LIFETIME (years)
Heavy Chemical	0.071-0.091	11-14
Oil and Gas Refining	0.063-0.071	14-16
Resins and Polymers	0.071-0.111	9-14
Food and Beverage	0.056-0.091	11-18
Pulp and Paper	0.063-0.100	10-16
Mining	0.063-0.100	10-18

AIR DRYER

AIR DRYER





REGIONAL ADJUSTMENT

Region	F_R
1	1.000
2	1.010
3	0.938
4	1.024
5	1.121
6	1.031
7	1.044
8	1.054
9	1.050
10	1.010

Installed air dryer cost includes purchased cost of air dryer, handling and setting, piping, concrete, steel, instrumentation, insulation, paint, and indirect costs (prime contractor engineering and construction overhead).

INSTALLED AIR DRYER COST,\$ = (INSTALLED BASE COST) (F_R)

ANNUAL MAINTENANCE

Annual maintenance will be approximately 1.56 percent of installed air dryer cost.

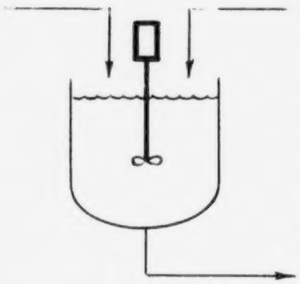
OPERATION COST

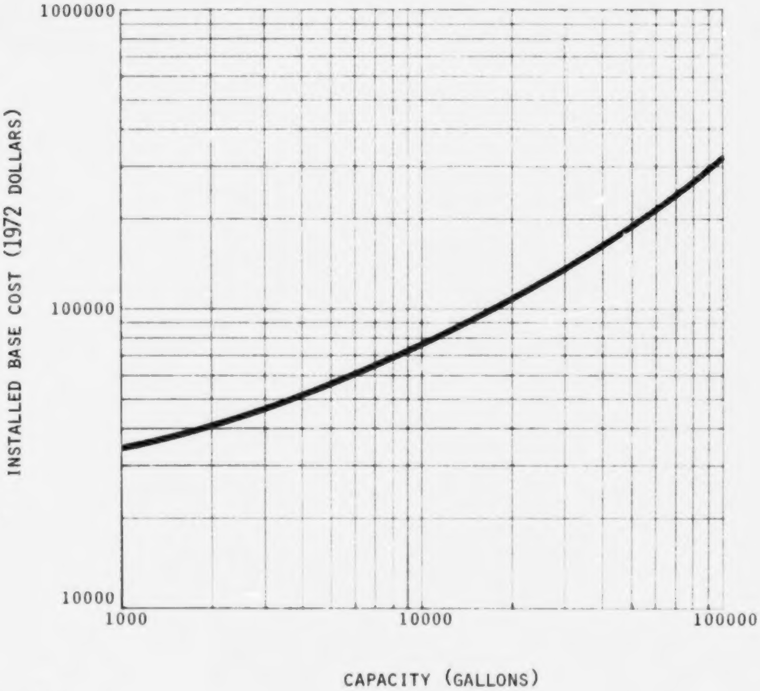
Air dryers require no operator attention.

PROBABLE ANNUAL DEPRECIATION RATE

INDUSTRY GROUP	DEPRECIATION RATE (percent)	EXPECTED LIFETIME (years)
Heavy Chemical	0.071-0.091	11-20
Oil and Gas Refining	0.063-0.071	14-16
Resins and Polymers	0.071-0.111	9-14
Food and Beverage	0.056- .091	11-18
Pulp and Paper	0.063-0.100	10-16
Mining	0.063-0.100	10-18

AGITATED OPEN TANK



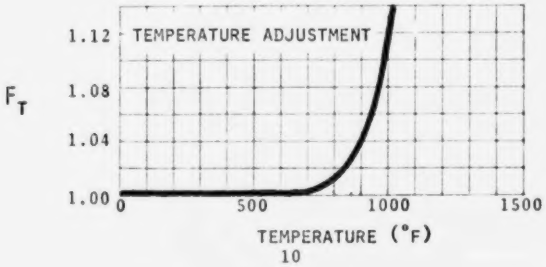


MATERIAL ADJUSTMENT

Material	F_M
CS	1.000
SS304	1.045
Al	1.750
Ni	2.025
Monel	1.924
Cu	1.739
Moly	2.578
Glass Lined CS	2.827
1/4 inch Rubber Lined CS	1.462
A 204 CS	1.504
Ti	2.056

REGIONAL ADJUSTMENT

Region	F_R
1	1.000
2	1.071
3	0.979
4	1.038
5	1.084
6	1.029
7	1.067
8	1.032
9	1.072
10	1.035



Installed agitated open tank cost includes purchased cost of agitated tank, impeller, motor and drive, handling and setting, piping, concrete, steel, instrumentation, electrical, insulation, paint, and indirect costs (prime contractor engineering and construction overhead).

INSTALLED AGITATED OPEN TANK COST,\$ = (INSTALLED BASE COST) (F_M) (F_R) (F_D) (F_T)

ANNUAL MAINTENANCE

Annual maintenance will vary from 7.38 to 10 percent of installed agitated open tank cost and will depend primarily upon severity of process conditions (temperature, cycling, viscosity).

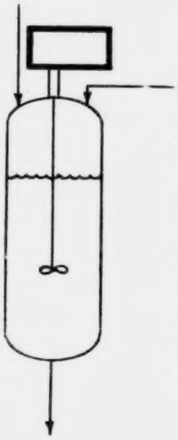
OPERATION COST

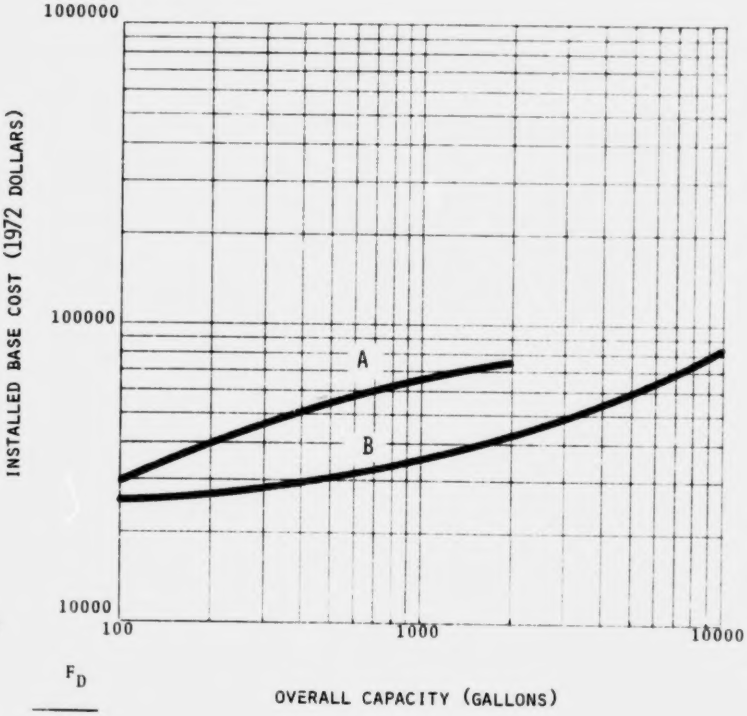
Agitated open tanks require between 0.25 and 0.5 operators per shift.

PROBABLE ANNUAL DEPRECIATION RATE

INDUSTRY GROUP	DEPRECIATION RATE (percent)	EXPECTED LIFETIME (years)
Heavy Chemical	0.071-0.091	11-20
Oil and Gas Refining	0.063-0.071	14-16
Resins and Polymers	0.071-0.111	9-14
Food and Beverage	0.056- .091	11-18
Pulp and Paper	0.063-0.100	10-16
Mining	0.063-0.100	10-18

AGITATED PRESSURE TANK




1000000
100000
10000
INSTALLED BASE COST (1972 DOLLARS)
A
B
100
1000
10000
OVERALL CAPACITY (GALLONS)

DESIGN ADJUSTMENT

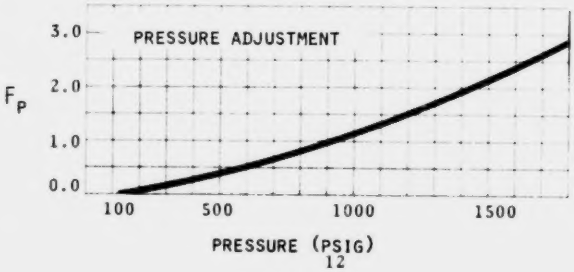
Type	Range (Gallons)	Curve	F_D
Autoclave	100-2000	A	1.0000
Mixer	100-10000	B	1.0000
Jacketed Reactor	100-2000	A	0.6635
ASME Code Designed	100-2000	B	1.0000

REGIONAL ADJUSTMENT

Region	F_R
1	1.000
2	1.068
3	0.981
4	1.036
5	1.078
6	1.028
7	1.065
8	1.031
9	1.069
10	1.034

MATERIAL ADJUSTMENT

Type	Material Symbol	F_M
Autoclave	CS	0.000
Autoclave	SS304	0.610
Mixer	CS	0.000
Mixer	SS304	0.110
Mixer	SS316	0.117
Mixer	SS347	0.179
Jacketed Reactor	SS304	0.065
Jacketed Reactor	Glass Lined CS	0.136



Installed agitated pressure tank cost includes purchased cost of agitated pressure tank (autoclaves include design by vendor, thermometer well, blow pipe, full vacuum rating), motor and drive, skirt, handling and setting, piping, concrete, steel, instrumentation, electrical, insulation, paint, and indirect costs (prime contractor engineering and construction overhead).

INSTALLED AGITATED PRESSURE TANK COST, $ = (INSTALLED BASE COST) $(F_D + F_M + F_P)(F_R)$

ANNUAL MAINTENANCE

Annual maintenance will be approximately 0.883 percent of installed agitated pressure tank cost and will primarily depend upon process conditions (temperature, pressure, viscosity, cycling).

OPERATION COST

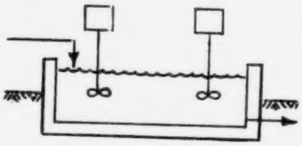
Agitated pressure tanks require between 0.25 and 1.00 operators per shift.

PROBABLE ANNUAL DEPRECIATION RATE

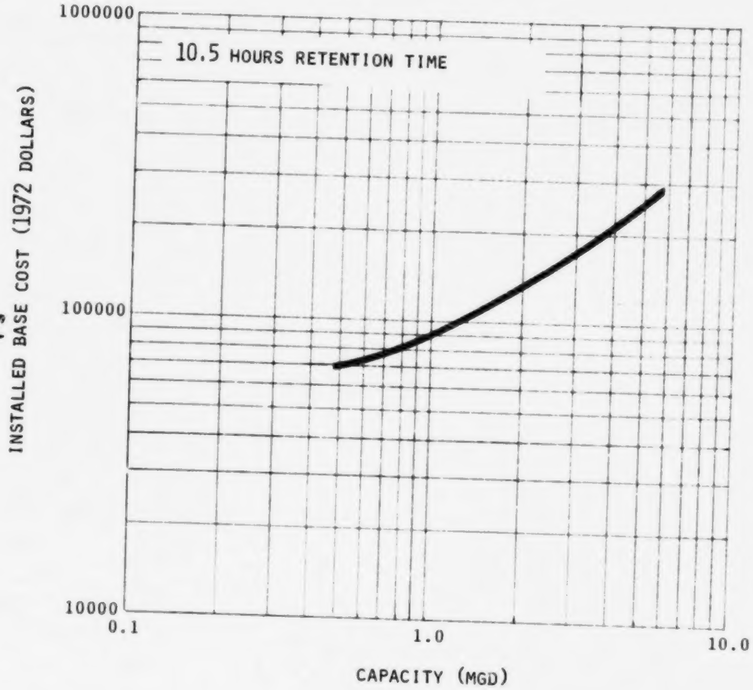
INDUSTRY GROUP	DEPRECIATION RATE (percent)	EXPECTED LIFETIME (years)
Heavy Chemical	0.071-0.091	11-20
Oil and Gas Refining	0.063-0.071	14-16
Resins and Polymers	0.071-0.111	9-14
Food and Beverage	0.056- .091	11-18
Pulp and Paper	0.063-0.100	10-16
Mining	0.063-0.100	10-18

AS-1

AERATION SYSTEM



AERATION SYSTEM



REGIONAL ADJUSTMENT

Region	F_R
1	1.000
2	1.045
3	0.947
4	1.043
5	1.133
6	1.041
7	1.066
8	1.065
9	1.067
10	1.029

Installed aeration system cost includes reinforced concrete basin, floating mechanical aerators, piping, concrete, steel, instrumentation, electrical, paint, and indirect costs (prime contractor engineering and construction overhead).

INSTALLED AERATION SYSTEM COST, \$ = (INSTALLED BASE COST)(F_R)

ANNUAL MAINTENANCE

Annual maintenance will be approximately 0.5 to 1.5 percent of installed aeration system cost.

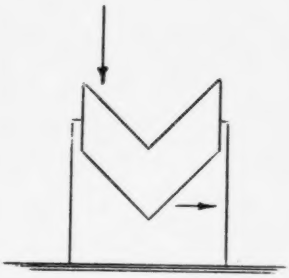
OPERATION COST

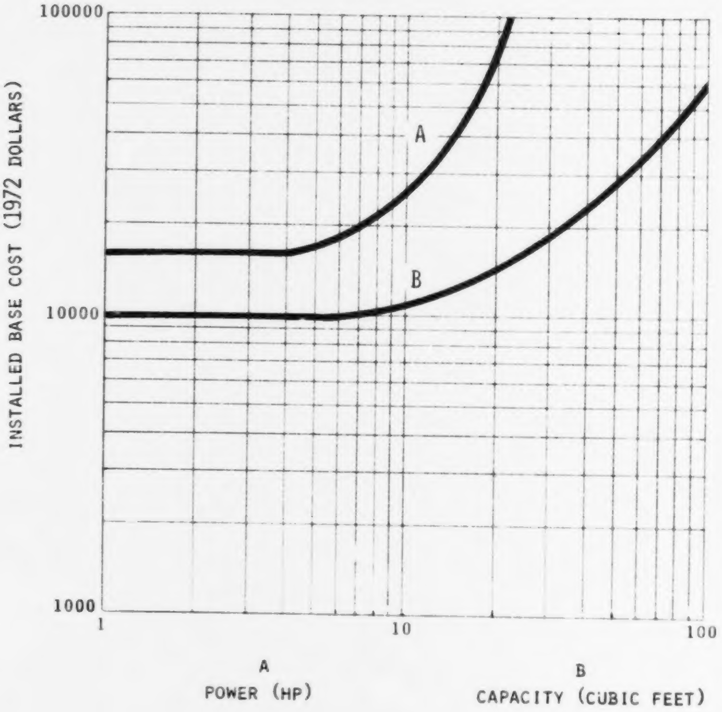
Aeration systems require no operator attention.

PROBABLE ANNUAL DEPRECIATION RATE

INDUSTRY GROUP	DEPRECIATION RATE (percent)	EXPECTED LIFETIME (years)
Heavy Chemical	0.016 - 0.040	25-60
Oil and Gas Refining	0.016 - 0.040	25-60
Resins and Polymers	0.016 - 0.040	25-60
Food and Beverage	0.016 - 0.040	25-60
Pulp and Paper	0.016 - 0.040	25-60
Mining	0.016 - 0.040	25-60

BLENDER





DESIGN ADJUSTMENT

Type	Curve	F_D
Rotary	A	1.000
Spiral Ribbon	B	1.000

REGIONAL ADJUSTMENT

Region	F_R
1	1.000
2	1.036
3	0.943
4	1.036
5	1.131
6	1.037
7	1.051
8	1.059
9	1.063
10	1.022

Installed blender cost includes purchased cost of blender, motor and drive, handling and setting, piping and ductwork, concrete, instrumentation, electrical, paint, and indirect costs (prime contractor engineering and construction overhead).

INSTALLED BLENDER COST, \$ = (INSTALLED BASE COST)$(F_D)(F_R)$

ANNUAL MAINTENANCE

Annual maintenance will be approximately 1.3 percent of installed blender cost and will primarily depend upon cycling, product characteristics and batch time.

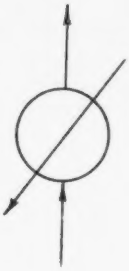
OPERATION COST

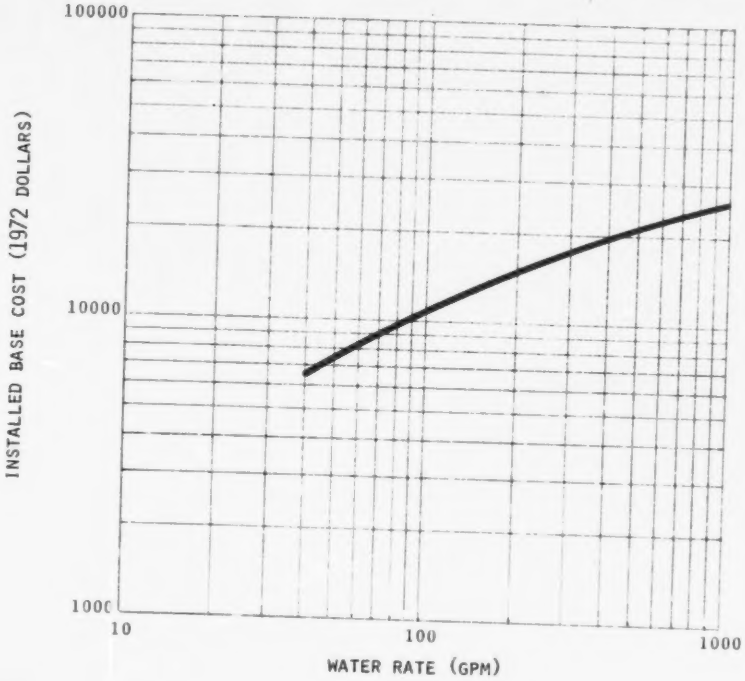
Blenders require between 0.125 and 0.5 operators per shift.

PROBABLE ANNUAL DEPRECIATION RATE

INDUSTRY GROUP	DEPRECIATION RATE (percent)	EXPECTED LIFETIME (years)
Heavy Chemical	0.05-0.091	11-20
Oil and Gas Refining	0.063-0.071	14-16
Resins and Polymers	0.071-0.111	9-14
Food and Beverage	0.056-0.091	11-18
Pulp and Paper	0.063-0.100	10-16
Mining	0.063-0.100	10-18

CONDENSER





MATERIAL ADJUSTMENT

Material	F_M
CI	1.000
CS	0.779
Rubber Lined CS	1.209

REGIONAL ADJUSTMENT

Region	F_R
1	1.000
2	1.068
3	0.981
4	1.034
5	1.079
6	1.026
7	1.062
8	1.025
9	1.070
10	1.031

Installed condenser cost includes purchased cost of barometric condenser, handling and setting, piping, concrete steel, instrumentation, electrical, insulation, paint, and indirect costs (prime contractor engineering and construction overhead).

INSTALLED CONDENSER COST,\$ = (INSTALLED BASE COST)$(F_M)(F_R)$

ANNUAL MAINTENANCE

Annual maintenance will vary from 0.75 to 0.90 percent of installed condenser cost and will depend upon severity of process conditions.

OPERATION COST

Condensers require no operator attention.

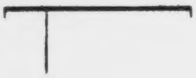
PROBABLE ANNUAL DEPRECIATION RATE

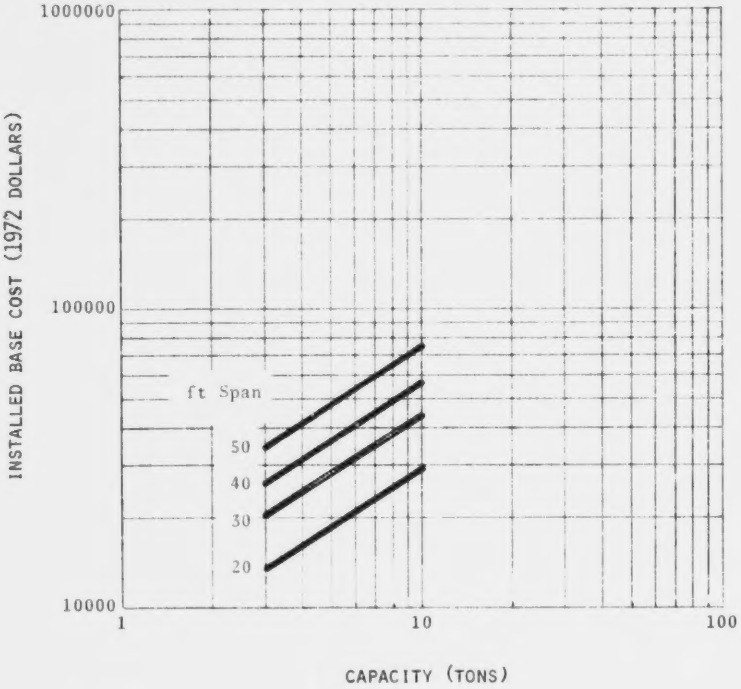
INDUSTRY GROUP	DEPRECIATION RATE (percent)	EXPECTED LIFETIME (years)
Heavy Chemical	0.071-0.091	11-14
Oil and Gas Refining	0.063-0.071	14-16
Resins and Polymers	0.071	14
Food and Beverage	0.056- .083	12-18
Pulp and Paper	0.063	16
Mining	0.063-0.100	10-18

CE-1

CRANE

CRANE





REGIONAL ADJUSTMENT

Region	F_R
1	1.000
2	1.040
3	0.995
4	1.022
5	1.040
6	1.036
7	1.027
8	1.018
9	1.031
10	1.018

Installed crane cost includes purchased cost of crane, field erection, steel, electrical, paint, and indirect costs (prime contractor engineering and construction overhead).

INSTALLED CRANE COST,\$ = (INSTALLED BASE COST) (F_R)

ANNUAL MAINTENANCE

Annual maintenance will vary from 2.11 to 2.14 of installed crane cost.

OPERATION COST

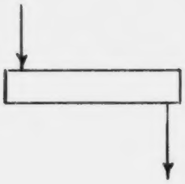
Cranes require no operator attention.

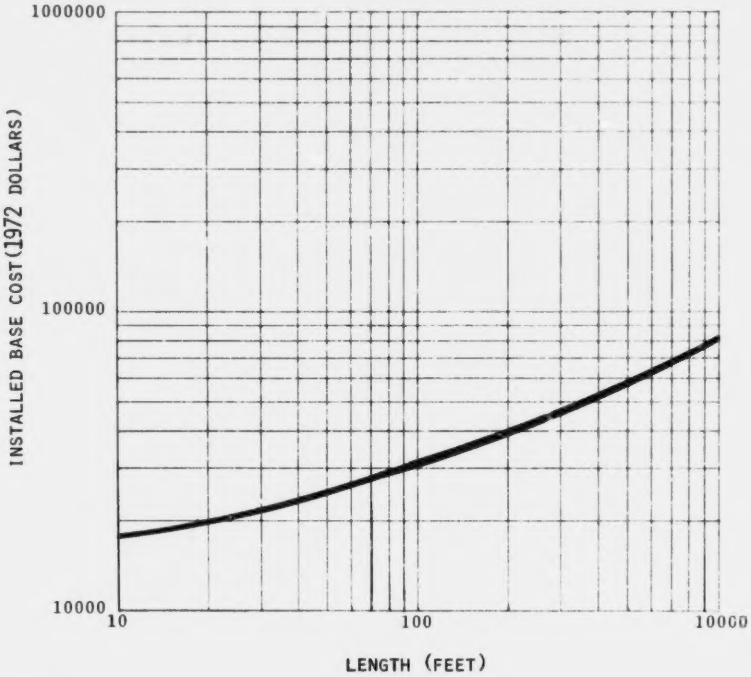
PROBABLE ANNUAL DEPRECIATION RATE

INDUSTRY GROUP	DEPRECIATION RATE (percent)	EXPECTED LIFETIME (years)
Heavy Chemical	0.05-0.091	11-20
Oil and Gas Refining	0.063-0.071	14-16
Resins and Polymers	0.071-0.111	9-14
Food and Beverage	0.056-0.091	11-18
Pulp and Paper	0.063-0.100	10-16
Mining	0.063-0.100	10-18

CO-1

CONVEYOR





DESIGN ADJUSTMENT

Type	F_D
Screw	1.000
Vibrating	0.148

REGIONAL ADJUSTMENT

Region	F_R
1	1.000
2	1.036
3	0.959
4	1.027
5	1.100
6	1.027
7	1.043
8	1.044
9	1.050
10	1.018

Installed conveyor cost includes purchased cost of conveyor, motor, and drive, handling and setting, ductwork, concrete, instrumentation, electrical, paint, and indirect costs (prime contractor engineering and construction overhead).

INSTALLED CONVEYOR COST, \$ = (INSTALLED BASE COST)$(F_R)(F_D)$

ANNUAL MAINTENANCE

Annual maintenance will vary from .32 to 6.85 percent of installed conveyor cost and will depend upon abrasiveness and particle size of material being transported.

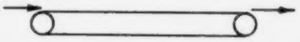
OPERATION COST

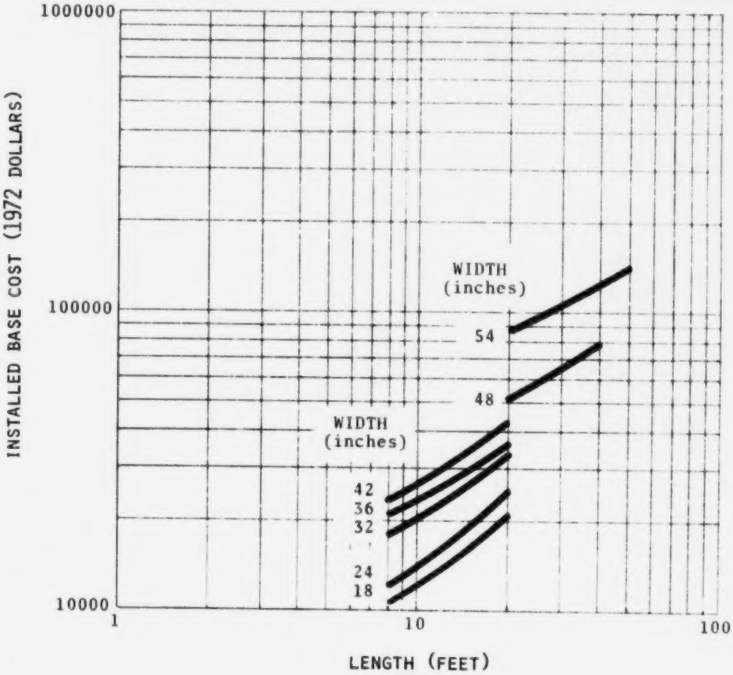
Conveyors require no operator attention. Operator attention is determined at processing functions at either end of conveyor.

PROBABLE ANNUAL DEPRECIATION RATE

INDUSTRY GROUP	DEPRECIATION RATE (percent)	EXPECTED LIFETIME (years)
Heavy Chemical	0.050-0.071	14-20
Oil and Gas Refining	0.063-0.071	14-16
Resins and Polymers	0.071-0.111	9-14
Food and Beverage	0.056-0.091	11-18
Pulp and Paper	0.063-0.100	10-16
Mining	0.063-0.100	10-18

APRON CONVEYOR





REGIONAL ADJUSTMENT

Region	F_R
1	1.000
2	1.037
3	0.959
4	1.027
5	1.100
6	1.027
7	1.042
8	1.045
9	1.050
10	1.019

Installed apron conveyor cost includes purchased cost of apron conveyor, motor and drive, handling and setting, ductwork concrete, instrumentation, electrical, paint, and indirect costs (prime contractor engineering and construction overhead).

INSTALLED APRON CONVEYOR COST,$ = (INSTALLED BASE COST) (F_R)

ANNUAL MAINTENANCE

Annual maintenance will vary from 0.142 to .265 percent of installed apron conveyor cost and will depend upon **abrasiveness and** particle size of material being conveyed.

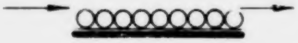
OPERATION COST

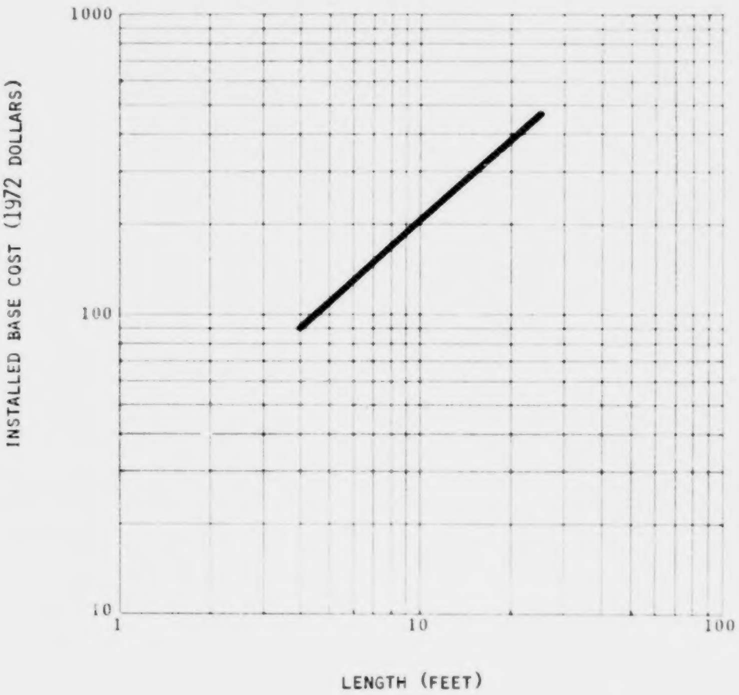
Apron conveyors require no operator attention. Operator attention is determined at processing steps at either end of conveyor.

PROBABLE ANNUAL DEPRECIATION RATE

INDUSTRY GROUP	DEPRECIATION RATE (percent)	EXPECTED LIFETIME (years)
Heavy Chemical	0.050-0.071	14-20
Oil and Gas Refining	0.063-0.071	14-16
Resins and Polymers	0.071-0.111	9-14
Food and Beverage	0.056-0.091	11-18
Pulp and **Paper**	0.063-0.100	10-16
Mining	0.063-0.100	10-18

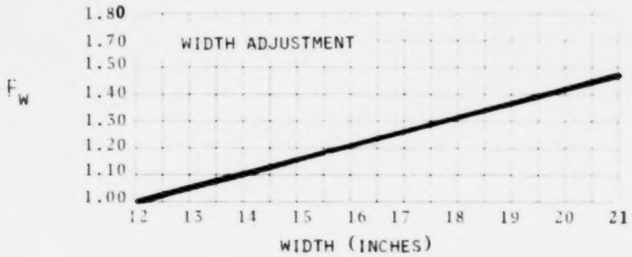
ROLLER CONVEYOR





REGIONAL ADJUSTMENT

Region	F_R
1	1.000
2	1.039
3	0.967
4	1.030
5	1.112
6	1.028
7	1.041
8	1.054
9	1.049
10	1.015



Installed roller conveyor cost includes purchased cost of roller conveyer, motor and drive, handling and setting, concrete, instrumentation, electrical, paint, and indirect costs (prime contractor engineering and construction overhead).

INSTALLED ROLLER CONVEYOR COST.$ = (INSTALLED BASE COST)(F_W)(F_R)

ANNUAL MAINTENANCE

Annual maintenance will vary from 6.56 to 6.67 percent of installed roller conveyor cost and will depend upon usage conditions (cycling, hours per day).

OPERATION COST

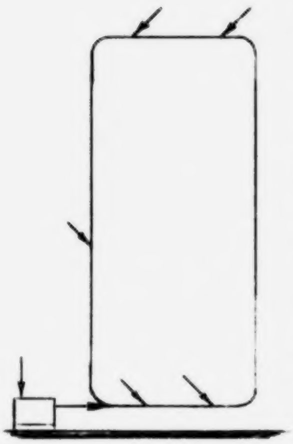
Roller conveyors require no operator attention.

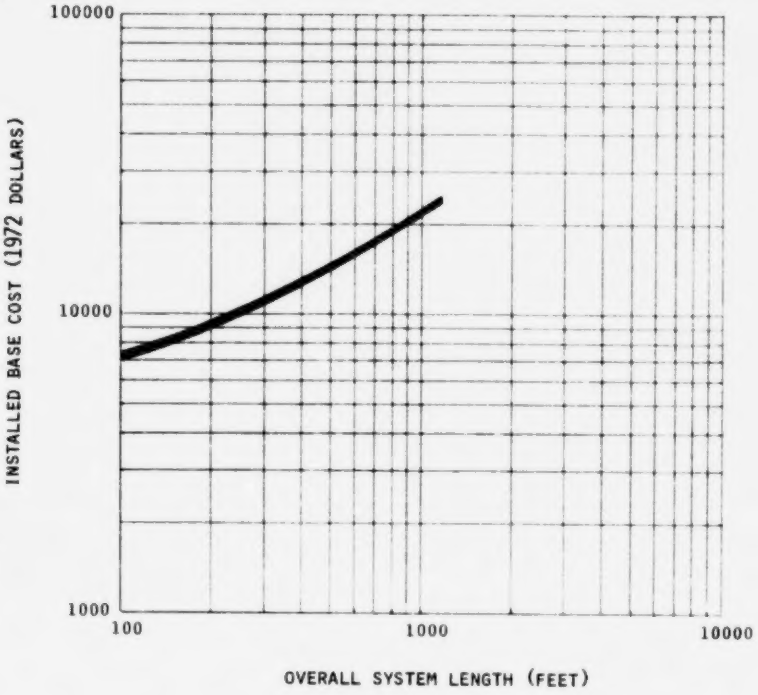
PROBABLE ANNUAL DEPRECIATION RATE

INDUSTRY GROUP	DEPRECIATION RATE (percent)	EXPECTED LIFETIME (years)
Heavy Chemical	0.050-0.071	14-20
Oil and Gas Refining	0.063-0.071	14-16
Resins and Polymers	0.071-0.111	9-14
Food and Beverage	0.056-0.091	11-18
Pulp and Paper	0.063-0.100	10-16
Mining	0.063-0.100	10-18

PNEUMATIC CONVEYING SYSTEM

PNEUMATIC CONVEYING SYSTEM



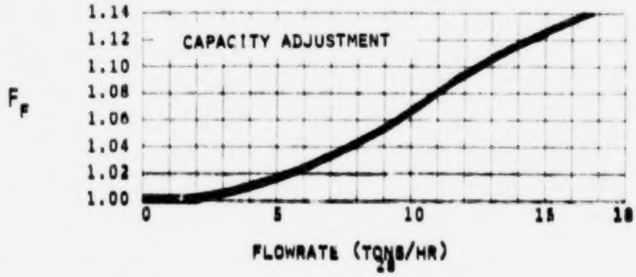

100000
10000
1000
INSTALLED BASE COST (1972 DOLLARS)
100
1000
10000
OVERALL SYSTEM LENGTH (FEET)

DESIGN ADJUSTMENT

Pipe Size	F_D
4 inch	1.000
3 inch	0.883

REGIONAL ADJUSTMENT

Region	F_R
1	1.000
2	1.036
3	0.962
4	1.031
5	1.106
6	1.030
7	1.044
8	1.048
9	1.055
10	1.020



Installed pneumatic conveying system cost includes purchased cost of pneumatic conveying system components, blower, motor, base, coupling, check valve, filter, field erection, piping, concrete, steel, instrumentation, electrical, paint, and indirect costs (prime contractor engineering and construction overhead).

INSTALLED PNEUMATIC CONVEYING SYSTEM COST,\$ = (INSTALLED BASE COST)$(F_D)(F_F)(F_R)$

ANNUAL MAINTENANCE

Annual maintenance will be approximately 7.44 percent of installed pneumatic conveying system cost and will depend upon hours of operation per day, cycling, fluid abrasiveness and particle size.

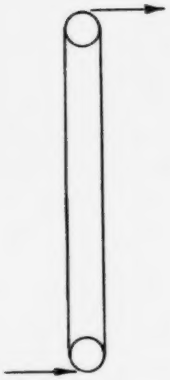
OPERATION COST

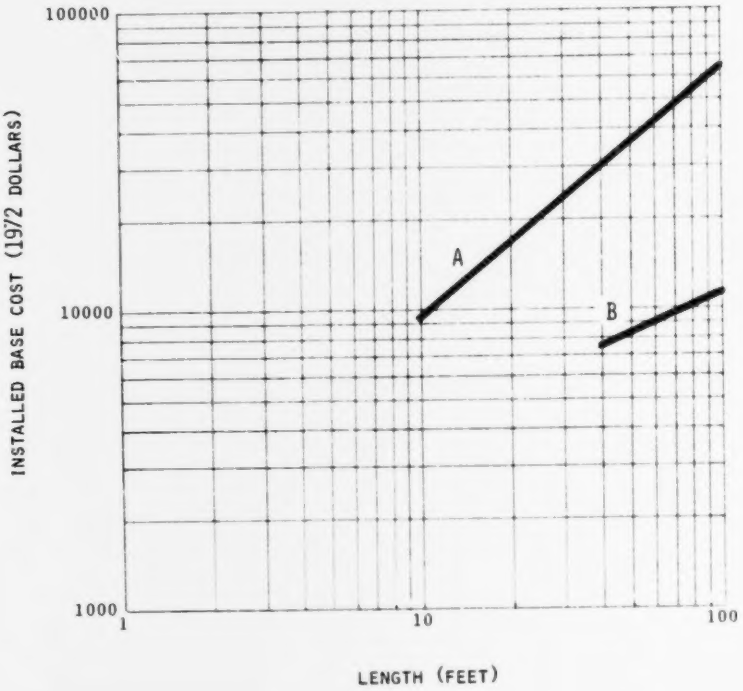
The pneumatic conveying system will require no operator attention.

PROBABLE ANNUAL DEPRECIATION RATE

INDUSTRY GROUP	DEPRECIATION RATE (percent)	EXPECTED LIFETIME (years)
Heavy Chemical	0.050-0.071	14-20
Oil and Gas Refining	0.063-0.071	14-16
Resins and Polymers	0.071-0.111	9-14
Food and Beverage	0.056-0.091	11-18
Pulp and Paper	0.063-0.100	10-16
Mining	0.063-0.100	10-18

BUCKET CONVEYOR





DESIGN ADJUSTMENT

Type	Bucket Size	Curve	F_D
Centrifugal Bucket	6 x 4	B	1.000
Centrifugal Bucket	8 x 5	B	1.163
Centrifugal Bucket	10 x 6	B	1.503
Centrifugal Bucket	12 x 7	B	1.694
Centrifugal Bucket	16 x 8	B	2.007
Continuous Bucket	8 x 5	B	1.283
Continuous Bucket	14 x 7	B	5.229
Continuous Bucket	15 x 8	B	6.525

Type	Width (Inches)	Curve	F_D
Closed Belt	36.0	A	1.000
Closed Belt	30.0	A	0.955
Closed Belt	24.0	A	0.889
Closed Belt	18.0	A	0.847
Open Belt	18.0	A	0.334
Open Belt	36.0	A	0.696
Open Belt	42.0	A	0.785
Open Belt	48.0	A	0.838

REGIONAL ADJUSTMENT

Region	F_R
1	1.000
2	1.036
3	0.959
4	1.027
5	1.100
6	1.027
7	1.043
8	1.044
9	1.050
10	1.018

Installed conveyor cost includes purchased cost of conveyor, motor and drive, handling and setting, ductwork, concrete, instrumentation, electrical, paint, and indirect costs (prime contractor engineering and construction overhead).

INSTALLED CONVEYOR COST.$ = (INSTALLED BASE COST) $(F_R)(F_D)$

ANNUAL MAINTENANCE

Annual maintenance will vary from .32 to 6.85 percent of installed conveyor cost and will depend upon abrasiveness and particle size of material being transported.

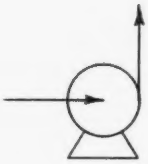
OPERATION COST

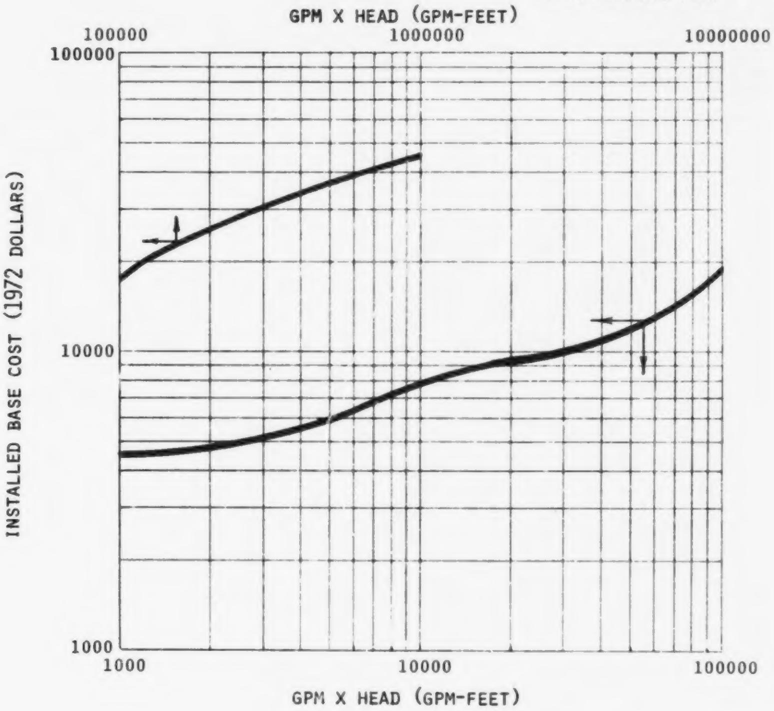
Conveyors require no operator attention. Operator attention is determined at processing functions at either end of conveyor.

PROBABLE ANNUAL DEPRECIATION RATE

INDUSTRY GROUP	DEPRECIATION RATE (percent)	EXPECTED LIFETIME (years)
Heavy Chemical	0.050-0.071	14-20
Oil and Gas Refining	0.063-0.071	14-16
Resins and Polymers	0.071-0.111	9-14
Food and Beverage	0.056-0.091	11-18
Pulp and Paper	0.063-0.100	10-16
Mining	0.063-0.100	10-18

CENTRIFUGAL PUMP





MATERIAL ADJUSTMENT

Material	F_M
CS	0.000
SS304	0.047
Ni	0.107
Worthite	0.077
Ti	0.457
Monel	0.101

DESIGN ADJUSTMENT

Type	F_D
American Voluntary Standards Heavy Duty	1.000
Heavy Duty	1.101
Moderate Service	1.001
General Service High Speed Open Impeller	0.950
General Service High Speed	0.976
General Service Medium Speed Open Impeller	0.942
Turbine Driven Multi Stage	1.190
Motor Driven Multi Stage	1.421

REGIONAL ADJUSTMENT

Region	F_R
1	1.000
2	1.067
3	0.978
4	1.038
5	1.083
6	1.026
7	1.056
8	1.027
9	1.068
10	1.030

Installed centrifugal pump cost includes purchased cost of centrifugal pump, base plate, coupling, driver, handling and setting, piping, concrete, instrumentation, electrical, insulation, paint, and indirect costs (prime contractor engineering and construction overhead).

INSTALLED CENTRIFUGAL PUMP COST,$ = (INSTALLED BASE COST)$(F_D + F_M)(F_R)$

ANNUAL MAINTENANCE

Annual maintenance will vary from 2.79 to 3.03 of the installed centrifugal pump cost and will depend upon operational hours per day, pressure, temperature, and fluid abrasiveness.

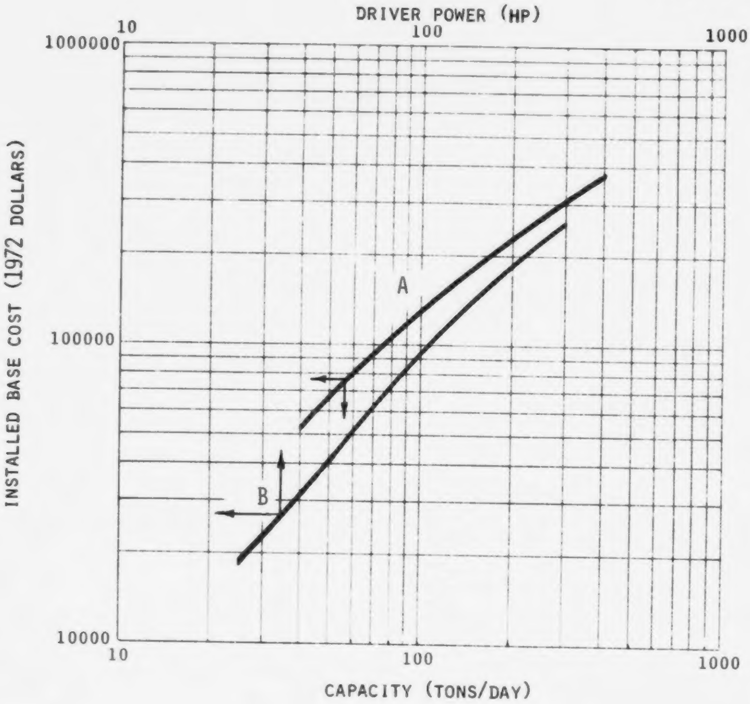
OPERATION COST

Centrifugal pumps require no operator attention.

PROBABLE ANNUAL DEPRECIATION RATE

INDUSTRY GROUP	DEPRECIATION RATE (percent)	EXPECTED LIFETIME (years)
Heavy Chemical	0.05-0.091	11-20
Oil and Gas Refining	0.063-0.071	14-16
Resins and Polymers	0.071-0.111	9-14
Food and Beverage	0.056-0.091	11-18
Pulp and Paper	0.063-0.100	10-16
Mining	0.063-0.100	10-18

CRUSHER



DESIGN ADJUSTMENT

Type	Curve	F_D
Cone Crusher	A	1.000
Gyratory Crusher	B	1.000
Jaw Crusher	B	1.092
Pulverizer	B	0.358
Roll Crusher	A	1.367
Rotary Crusher	B	0.744
Sawtooth Crusher	A	0.584

REGIONAL ADJUSTMENT

Region	F_R
1	1.000
2	1.017
3	0.936
4	1.026
5	1.127
6	1.032
7	1.042
8	1.059
9	1.049
10	1.012

Installed crusher cost includes purchased cost of crusher, handling and setting, ductwork, concrete, instrumentation, electrical, paint, and indirect costs (prime contractor engineering and construction overhead).

INSTALLED CRUSHER COST.\$ = (INSTALLED BASE COST) $(F_D)(F_R)$

ANNUAL MAINTENANCE

Annual maintenance will vary from 1.51 to 1.66 percent of the installed crusher cost and be dependent upon abrasiveness of material being comminuted.

OPERATION COST

Crusher requires between approximately 0.5 operators per shift.

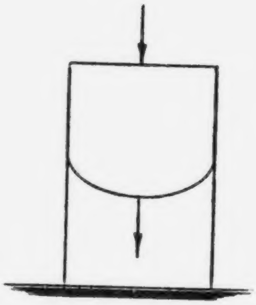
PROBABLE ANNUAL DEPRECIATION RATE

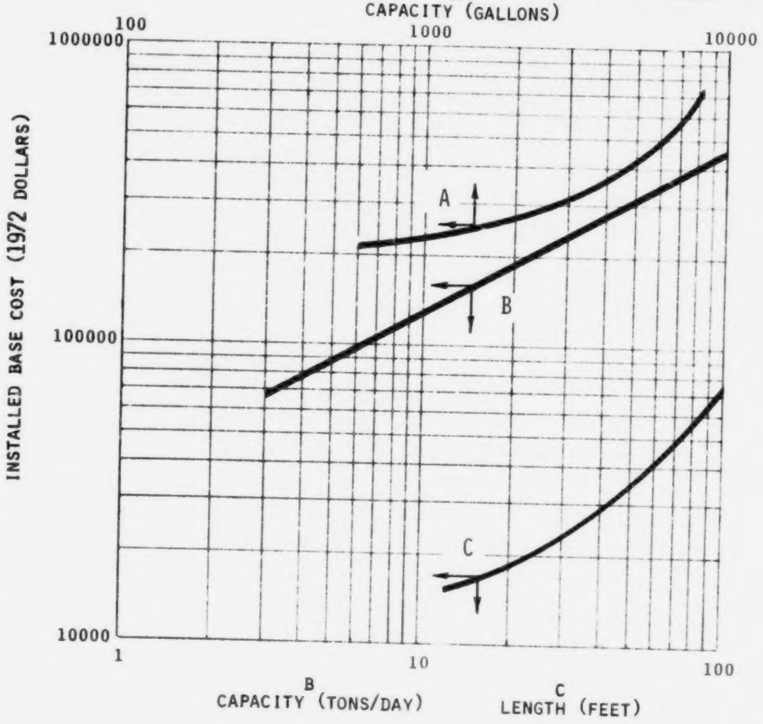
INDUSTRY GROUP	DEPRECIATION RATE (percent)	EXPECTED LIFETIME (years)
Heavy Chemical	0.071-0.091	11-14
Oil and Gas Refining	0.063-0.071	14-16
Resins and Polymers	0.071	14
Food and Beverage	0.083	12
Pulp and Paper	0.100	10
Mining	0.063-0.100	10-18

CRY-1

CRYSTALLIZER

CRYSTALLIZER





DESIGN ADJUSTMENT

Type	Curve	F_D
Batch Vacuum	A	0.00
Forced Circulation	B	0.00
Mechanical	C	0.00
Oslo	B	0.64

REGIONAL ADJUSTMENT

Region	F_R
1	1.000
2	1.043
3	0.949
4	1.041
5	1.133
6	1.041
7	1.064
8	1.066
9	1.067
10	1.027

Installed crystallizer cost includes purchased cost of crystallizer handling and setting, piping, concrete, steel, instrumentation, electrical, insulation, paint, and indirect costs (prime contractor engineering and construction overhead).

INSTALLED CRYSTALLIZER COST,\$ = (INSTALLED BASE COST) $(F_R + F_D)$

ANNUAL MAINTENANCE

Annual maintenance will vary from 1.68 to 5.38 percent of the installed crystallizer cost and will depend upon fluid abrasiveness, temperature, and throughput.

OPERATION COST

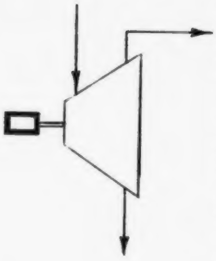
Crystallizers require between .16 and 0.5 operators per shift.

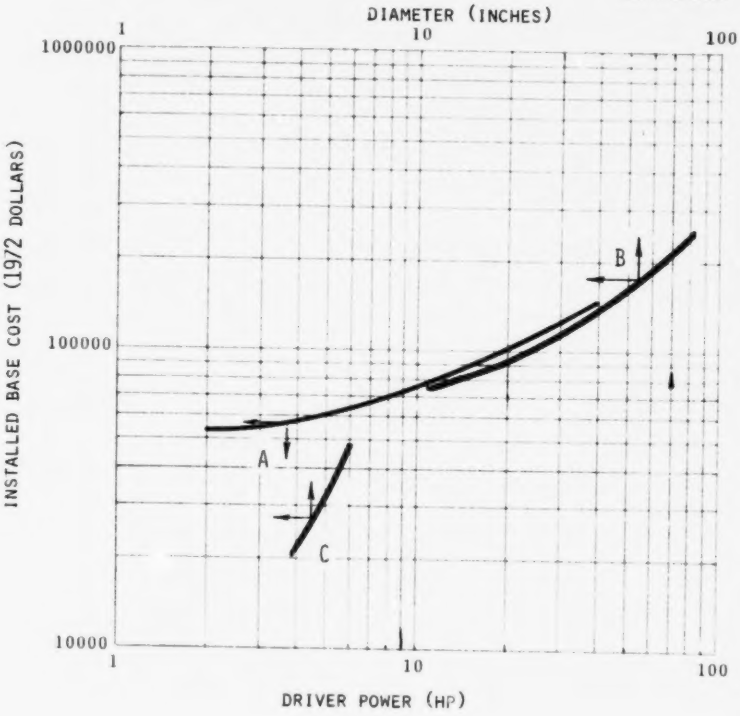
PROBABLE ANNUAL DEPRECIATION RATE

INDUSTRY GROUP	DEPRECIATION RATE (percent)	EXPECTED LIFETIME (years)
Heavy Chemical	0.091	11
Oil and Gas Refining	0.063-0.071	14-16
Resins and Polymers	0.071	14
Food and Beverage	0.056-0.083	12-18
Pulp and Paper	0.063-0.100	10-16
Mining	0.063-0.100	10-18

CENTRIFUGE

CENTRIFUGE





DESIGN ADJUSTMENT

Type	Curve	F_D
ATM Suspended	A	1.000
Batch Automatic	B	1.000
Batch Bottom	B	0.139
Batch Top	B	0.165
Disk	B	2.802
Reciprocating Conveyor	B	2.537
Scroll Conveyor	B	2.095
Solid Bowl	B	0.659
Tubular	C	1.000
Super D	B	0.630

REGIONAL ADJUSTMENT

Region	F_R
1	1.000
2	1.046
3	0.947
4	1.042
5	1.133
6	1.041
7	1.064
8	1.068
9	1.064
10	1.029

Installed centrifuge cost includes purchased cost of centrifuge, motor and drive, handling and setting piping, concrete, steel, instrumentation, electrical, insulation, paint, and indirect costs (prime contractor engineering and construction overhead).

INSTALLED CENTRIFUGE COST,\$ = (INSTALLED BASE COST)$(F_D)(F_R)$

ANNUAL MAINTENANCE

Annual maintenance will vary from 0.326 - 4.39 percent of installed centrifuge cost and will depend on cycle time, fluid clogging characteristics, temperature and pressure.

OPERATION COST

Centrifuges require between 0.10 and 0.25 operators per shift.

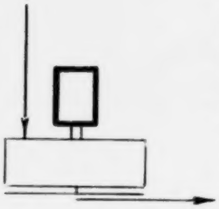
PROBABLE ANNUAL DEPRECIATION RATE

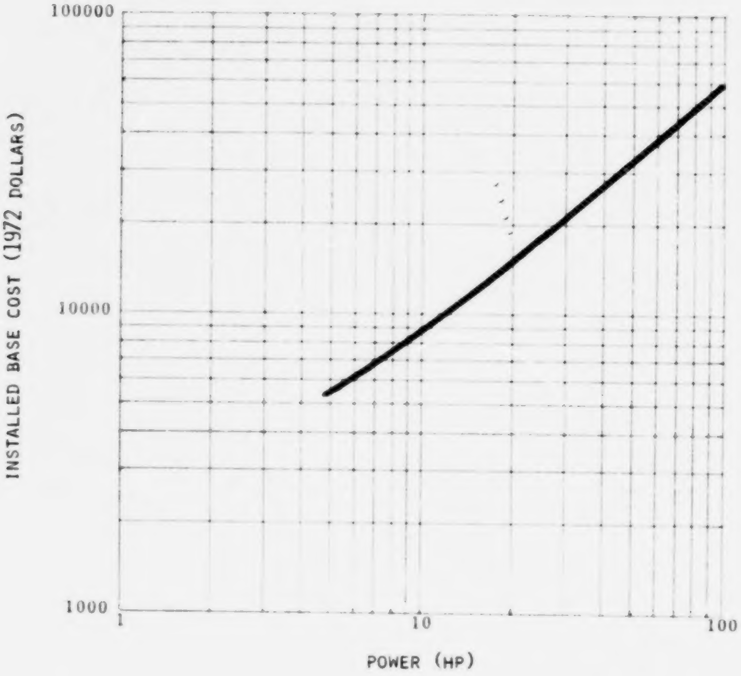
INDUSTRY GROUP	DEPRECIATION RATE (percent)	EXPECTED LIFETIME (years)
Heavy Chemical	0.05-0.091	11-20
Oil and Gas Refining	0.063-0.071	14-16
Resins and Polymers	0.071-0.111	9-14
Food and Beverage	0.056-0.091	11-18
Pulp and Paper	0.063-0.100	10-16
Mining	0.063-0.100	10-18

CU-1

CUTTER

CUTTER





REGIONAL ADJUSTMENT

Region	F_R
1	1.000
2	1.021
3	0.931
4	1.029
5	1.142
6	1.036
7	1.052
8	1.063
9	1.058
10	1.016

Installed cutter cost includes purchased cost of cutter, motor and drive, handling and setting, piping, concrete, steel, instrumentation, electrical, paint, and indirect costs (prime contractor engineering and construction overhead).

INSTALLED CUTTER COST,$ = (INSTALLED BASE COST)(F_R)

ANNUAL MAINTENANCE

Annual maintenance will vary from 1.33 - 1.39 of installed cutter cost and will depend upon cycle time, material hardness and process throughput.

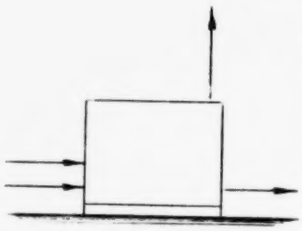
OPERATION COST

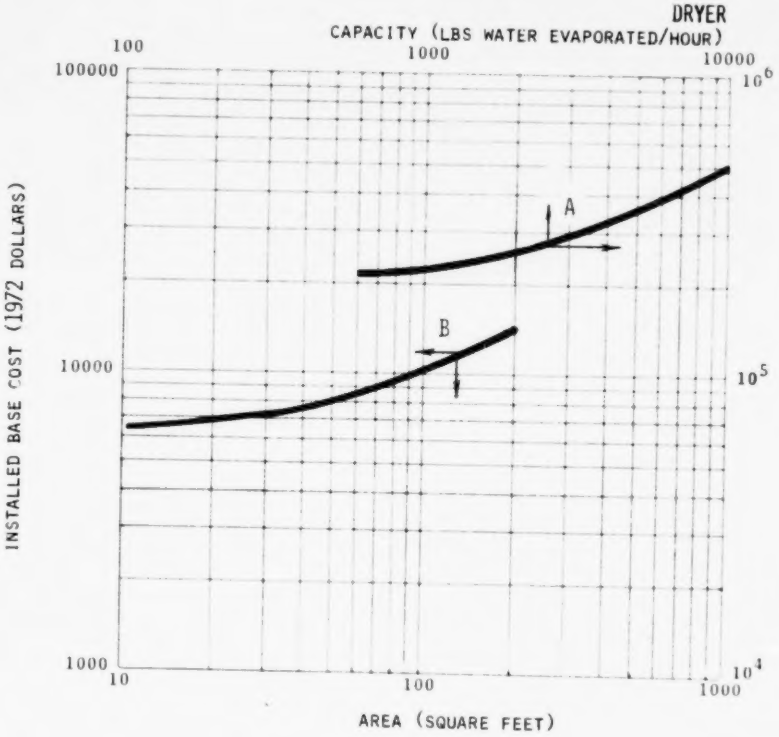
Cutters require between 0 and 0.25 operators per shift.

PROBABLE ANNUAL DEPRECIATION RATE

INDUSTRY GROUP	DEPRECIATION RATE (percent)	EXPECTED LIFETIME (years)
Heavy Chemical	0.091	11
Oil and Gas Refining	0.063-0.071	14-16
Resins and Polymers	0.071-0.111	9-14
Food and Beverage	0.067-0.091	11-15
Pulp and Paper	0.063-0.100	10-16
Mining	0.063-0.100	10-18

DRYER





DESIGN ADJUSTMENT

Type	Curves	F_D
Atmospheric Tray	B	1.000
Pan	B	3.766
Spray	A	1.000
Vacuum Tray		1.681

MATERIAL ADJUSTMENT

Material	F_M
CS	0.000
SS	0.640

REGIONAL ADJUSTMENT

Region	F_R
1	1.000
2	1.057
3	0.964
4	1.041
5	1.111
6	1.036
7	1.063
8	1.053
9	1.071
10	1.033

Installed dryer cost includes purchased cost of dryer and accessories (motor and drive for appropriate types), handling and setting, piping and ductwork, concrete, steel, instrumentation, electrical, insulation, paint, and indirect costs (prime contractor engineering and construction overhead).

INSTALLED DRYER COST.\$ = (INSTALLED BASE COST) $(F_D + F_M)(F_R)$

ANNUAL MAINTENANCE

Annual maintenance will vary from 0.163 - 2.36 of the installed dryer cost and will depend upon cycle time, and operating hours per year.

OPERATION COST

Dryers require between 0.2 and 0.5 operators per shift.

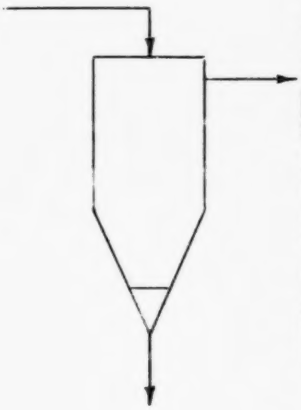
PROBABLE ANNUAL DEPRECIATION RATE

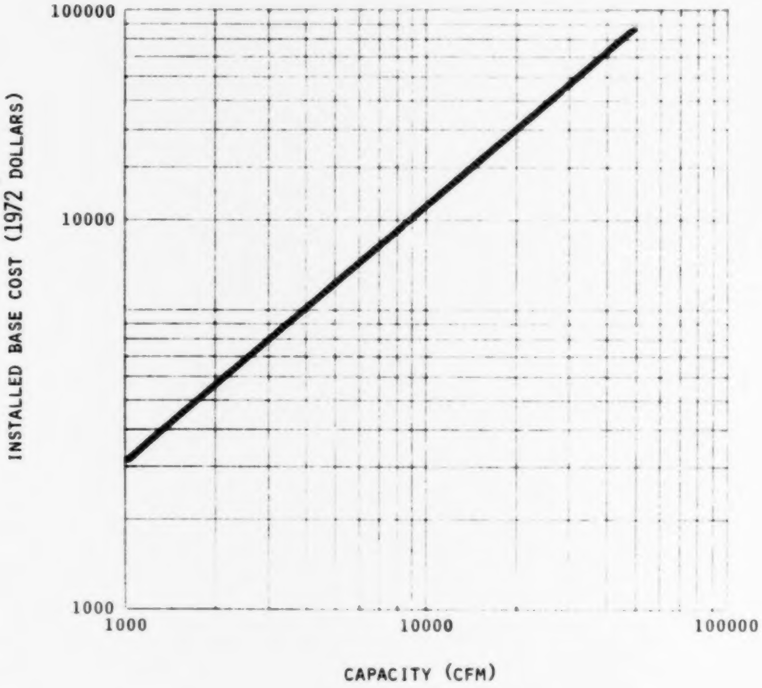
INDUSTRY GROUP	DEPRECIATION RATE (percent)	EXPECTED LIFETIME (years)
Heavy Chemical	0.050-0.091	11-20
Oil and Gas Refining	0.063-0.071	14-16
Resins and Polymers	0.071-0.111	9-14
Food and Beverage	0.056-0.833	12-18
Pulp and Paper	0.063-0.100	10-16
Mining	0.063-0.100	10-18

DC-1

DUST COLLECTOR

DUST COLLECTOR





DESIGN ADJUSTMENT

Type	F_D
Cloth Bay	1.000
Centrifugal Precipitator	0.840
Cyclone	1.213
Electrical Precipitator Hi-Voltage	5.060
Electrical Precipitator Low Voltage	3.403
Multiple Cyclone	0.327
Washers	0.967
Automatic Cloth Filter	0.658

REGIONAL ADJUSTMENT

Region	F_R
1	1.000
2	1.060
3	0.982
4	1.032
5	1.070
6	1.024
7	1.052
8	1.028
9	1.056
10	1.028

Installed dust collector cost includes purchased cost of dust collector (motor and drive for applicable types) handling and setting, piping and ductwork, concrete, steel, instrumentation, electrical (if required), insulation, paint, and indirect costs (prime contractor engineering and construction overhead).

INSTALLED DUST COLLECTOR COST.$ = (INSTALLED BASE COST)$(F_D)(F_R)$

ANNUAL MAINTENANCE

Annual maintenance will vary from 1.40 - 5.37 percent of the installed dust collector and will depend upon air/media ratio, fluid abrasiveness, particle size, cycle time, and operating hours per year.

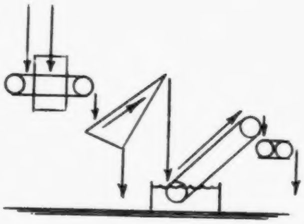
OPERATION COST

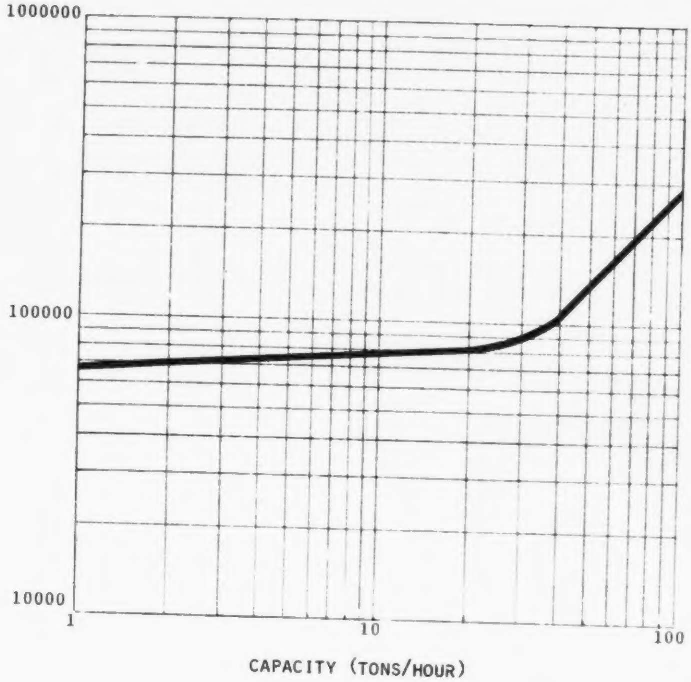
Dust collectors require between 0 and 0.05 operators per shift.

PROBABLE ANNUAL DEPRECIATION RATE

INDUSTRY GROUP	DEPRECIATION RATE (percent)	EXPECTED LIFETIME (years)
Heavy Chemical	0.050-0.091	11-20
Oil and Gas Refining	0.045	22
Resins and Polymers	0.045	22
Food and Beverage	0.045	22
Pulp and Paper	0.045	22
Mining	0.045	22

DRY CAUSTIC PEELER





REGIONAL ADJUSTMENT

Region	F_R
1	1.000
2	1.037
3	0.959
4	1.027
5	1.100
6	1.026
7	1.041
8	1.044
9	1.050
10	1.019

Installed dry caustic peeler cost includes purchased cost of dry peeler, holding tank, lye applicator, rinse tank, sprays, flight elevator, troughed conveyor, pumps, drives, ductwork and chutes, handling and setting, piping, concrete, steel, instrumentation, electrical, paint, and indirect costs (prime contractor engineering and construction overhead).

INSTALLED DRY CAUSTIC PEELER COST,\$ = (INSTALLED BASE COST)(F_R)

ANNUAL MAINTENANCE

Annual maintenance will be approximately 2 percent of the installed dry caustic peeler and will be dependent upon cycling and throughput.

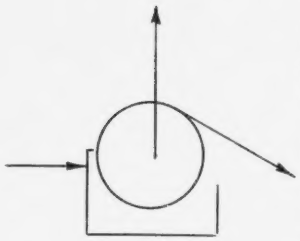
OPERATION COST

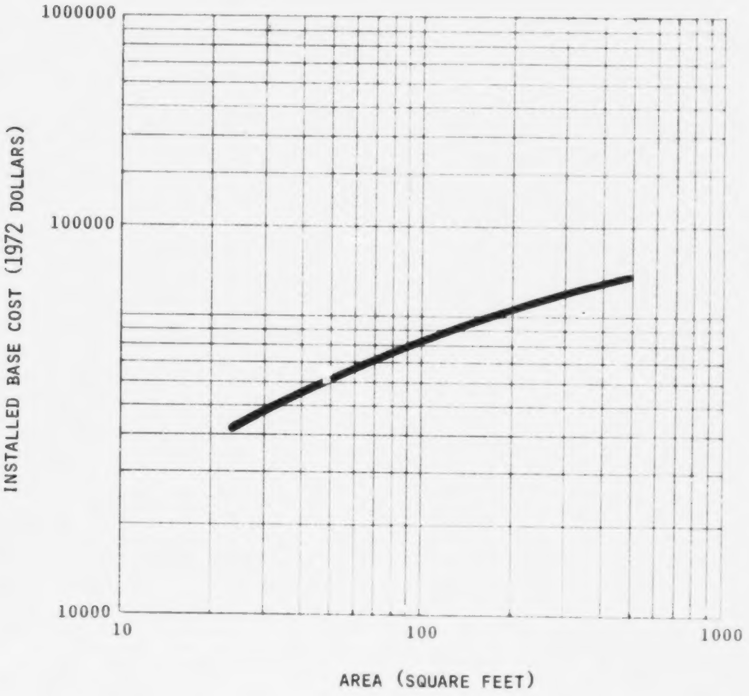
Dry caustic peelers require between 0.25 and 1.0 operators per shift.

PROBABLE ANNUAL DEPRECIATION RATE

INDUSTRY GROUP	DEPRECIATION RATE (percent)	EXPECTED LIFETIME (years)
Heavy Chemical	0.050-0.071	14-20
Oil and Gas Refining	0.063-0.071	14-16
Resins and Polymers	0.071-0.111	9-14
Food and Beverage	0.056-0.091	11-18
Pulp and Paper	0.063-0.100	10-16
Mining	0.063-0.100	10-18

DRUM DRYER





DESIGN ADJUSTMENT

Type	F_D
Double Atmospheric	1.000
Single Atmospheric	0.909
Single Vacuum	2.683

REGIONAL ADJUSTMENT

Region	F_R
1	1.000
2	1.052
3	0.965
4	1.039
5	1.104
6	1.033
7	1.060
8	1.050
9	1.062
10	1.029

Installed drum dryer cost includes purchased cost of drum dryer, motor, drive, handling and setting, piping and ductwork, concrete, steel, instrumentation, electrical, insulation, paint, and indirect costs (prime contractor engineering and construction overhead).

INSTALLED DRUM DRYER COST.$ = (INSTALLED BASE COST) $(F_D)(F_R)$

ANNUAL MAINTENANCE

Annual maintenance will vary from 0.46 - 0.55 percent of installed drum dryer cost and will depend upon cycle time and operating hours per year.

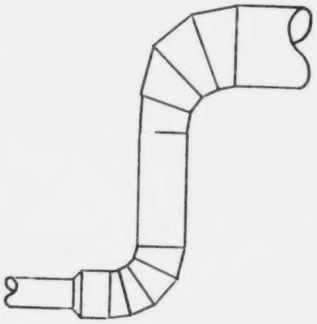
OPERATION COST

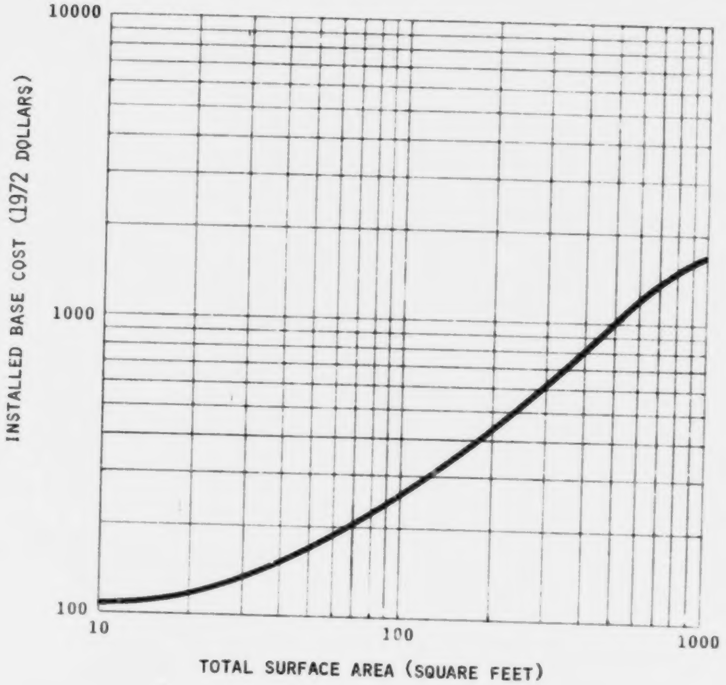
Drum dryers require between 0.2 and 0.5 operators per shift.

PROBABLE ANNUAL DEPRECIATION RATE

INDUSTRY GROUP	DEPRECIATION RATE (percent)	EXPECTED LIFETIME (years)
Heavy Chemical	0.05-0.091	11-20
Oil and Gas Refining	0.063-0.071	14-16
Resins and Polymers	0.071-0.111	9-14
Food and Beverage	0.056-0.091	11-18
Pulp and Paper	0.063-0.100	10-16
Mining	0.063-0.100	10-18

DUCTWORK




10000
1000
100
10
100
1000
INSTALLED BASE COST (1972 DOLLARS)
TOTAL SURFACE AREA (SQUARE FEET)

REGIONAL ADJUSTMENT

Region	F_R
1	1.000
2	1.427
3	0.913
4	1.132
5	1.416
6	1.133
7	1.353
8	1.120
9	1.060
10	1.179

Installed ductwork cost includes purchased cost of metal and accessories, handling and setting, and indirect costs (prime contractor engineering and construction overhead).

INSTALLED DUCTWORK COST,\$ = (INSTALLED BASE COST)(F_R)

ANNUAL MAINTENANCE

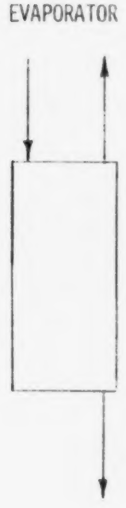
Annual maintenance will vary from 2 to 8 percent of installed ductwork cost and will primarily depend upon gas/media ratio and fluid abrasiveness.

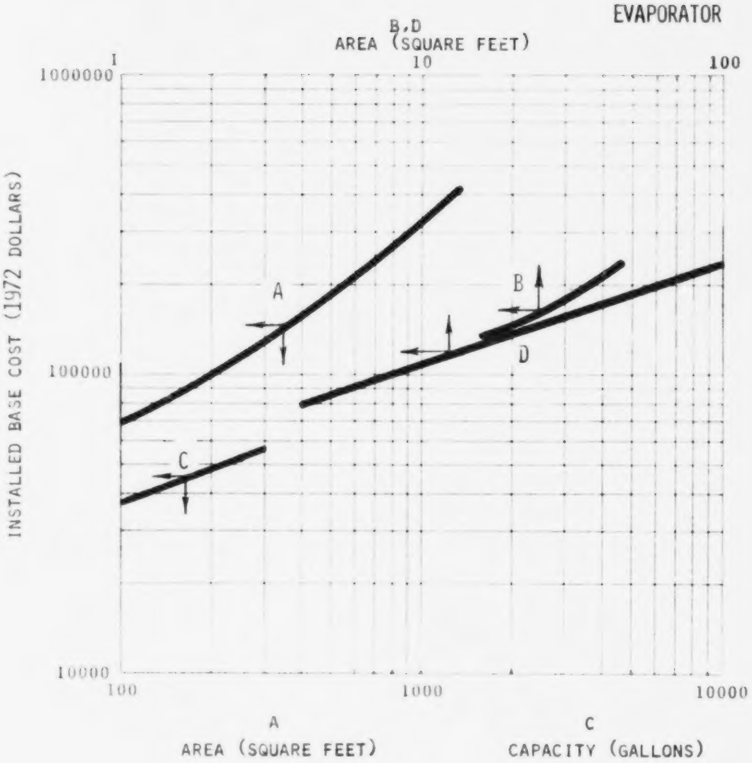
OPERATION COST

Ductwork requires no operator attention.

PROBABLE ANNUAL DEPRECIATION RATE

INDUSTRY GROUP	DEPRECIATION RATE (percent)	EXPECTED LIFETIME (years)
Heavy Chemical	0.050-0.091	11-20
Oil and Gas Refining	0.045	22
Resins and Polymers	0.045	22
Food and Beverage	0.045	22
Pulp and Paper	0.045	22
Mining	0.045	22





REGIONAL ADJUSTMENT

Region	F_R
1	1.000
2	1.074
3	0.979
4	1.036
5	1.079
6	1.027
7	1.071
8	1.026
9	1.069
10	1.036

DESIGN ADJUSTMENT

Type	Curve	F_D	Base Material
Forced Circulation	A	1.000	CS
Long Tube	B	1.000	SS
Standard Horizontal	A	0.617	CS
Standard Vertical	A	1.137	CS
Jacketed	C	1.000	Glass Lined CS
Long Vertical	A	0.318	CS
Falling Film	D	1.000	SS

MATERIAL ADJUSTMENT

Material	Base Material	F_M
Karbate Tube/CS Shell	CS	4.458
Pb Tube/Pb Lined CS Shell	CS	1.852
Cu Tube/CI Shell	CS	0.933

Installed evaporator cost includes purchased cost of evaporator, accessories, handling and setting, piping, concrete, steel, instrumentation, electrical, insulation, paint, and indirect costs (prime contractor engineering and construction overhead).

INSTALLED EVAPORATOR COST,\$ = (INSTALLED BASE COST)$(F_D)(F_M)(F_R)$

ANNUAL MAINTENANCE

Annual maintenance will vary from 0.20 - 4.31 percent of the installed evaporator cost and will depend upon operating hours per year, fluid viscosity, cycle time and temperature and pressure.

OPERATION COST

Evaporators require between 0.2 and 0.5 operators per shift.

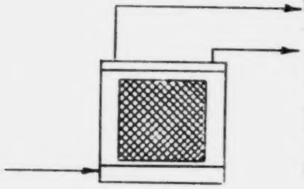
PROBABLE ANNUAL DEPRECIATION RATE

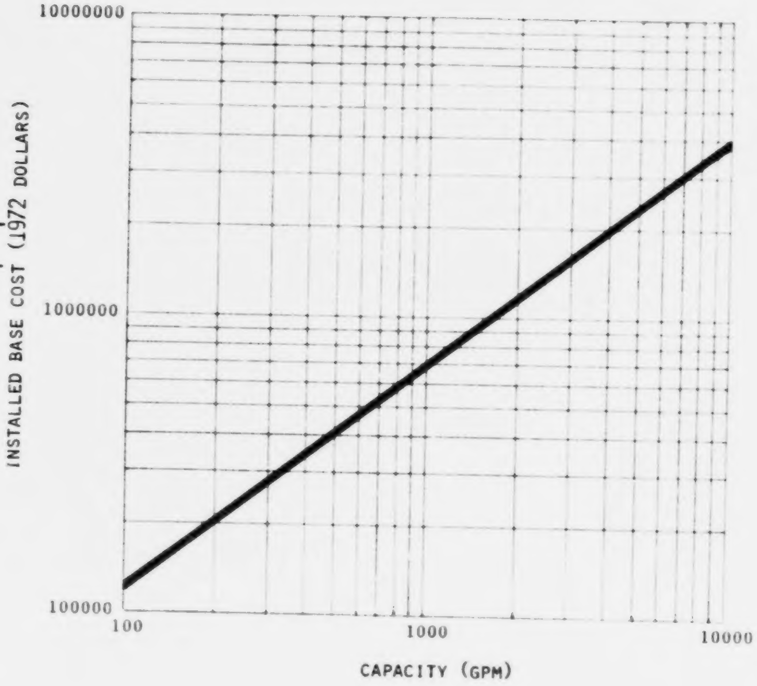
INDUSTRY GROUP	DEPRECIATION RATE (percent)	EXPECTED LIFETIME (years)
Heavy Chemical	0.091	11
Oil and Gas Refining	0.063-0.071	14-16
Resins and Polymers	0.071	14
Food and Beverage	0.056-0.083	12-18
Pulp and Paper	0.063-0.100	10-16
Mining	0.063-0.100	10-18

ED-1

ELECTRODIALYSIS

ELECTRODIALYSIS





REGIONAL ADJUSTMENT

Region	F_R
1	1.000
2	1.022
3	0.931
4	1.039
5	1.152
6	1.045
7	1.062
8	1.077
9	1.062
10	1.021

Installed electrodialysis module cost includes purchased cost of membrane stocks pumps, and accessories, field erection, piping, concrete, steel, instrumentation, electrical, paint, and indirect costs (prime contractor engineering and construction overhead).

INSTALLED ELECTRODIALYSIS COST,\$ = (INSTALLED BASE COST)(F_R)

ANNUAL MAINTENANCE

Annual maintenance will be approximately 5 percent of installed electrodialysis module and will **depend** upon processing conditions and membrane life.

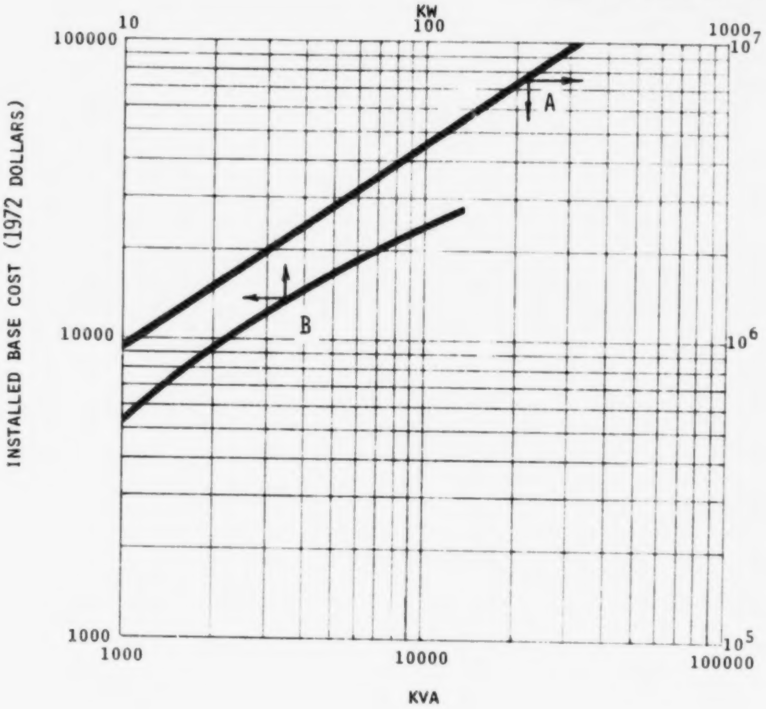
OPERATION COST

Electrodialysis modules require between 0.25 and 1 operator per shift.

PROBABLE ANNUAL DEPRECIATION RATE

INDUSTRY GROUP	DEPRECIATION RATE (percent)	EXPECTED LIFETIME (years)
Heavy Chemical	0.05-0.091	11-20
Oil and Gas Refining	0.063-0.071	14-16
Resins and Polymers	0.071-0.111	9-14
Food and Beverage	0.056-0.091	11-18
Pulp and Paper	0.063-0.100	10-16
Mining	0.063-0.100	10-18

ELECTRIC GENERATOR



DESIGN ADJUSTMENT

Type	Curve	F_D
Portable	B	1.000
Turbo Generator	A	1.000
Unit Steam	A	2.317

REGIONAL ADJUSTMENT

Region	F_R
1	1.000
2	1.001
3	0.934
4	1.026
5	1.128
6	1.035
7	1.030
8	1.067
9	1.037
10	1.008

Installed electrical generator cost includes purchased cost of electrical generator, accessories, handling and setting, interconnecting if required, piping, concrete, instrumentation, electrical, insulation if required, paint, and indirect costs (prime contractor engineering and construction overhead).

INSTALLED ELECTRICAL GENERATOR COST.\$ = (INSTALLED BASE COST) $(F_D)(F_R)$

ANNUAL MAINTENANCE

Annual maintenance will vary from 1.7 - 2.0 percent of installed electrical generator cost

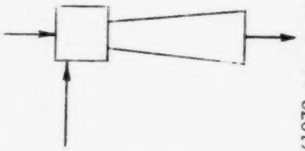
OPERATION COST

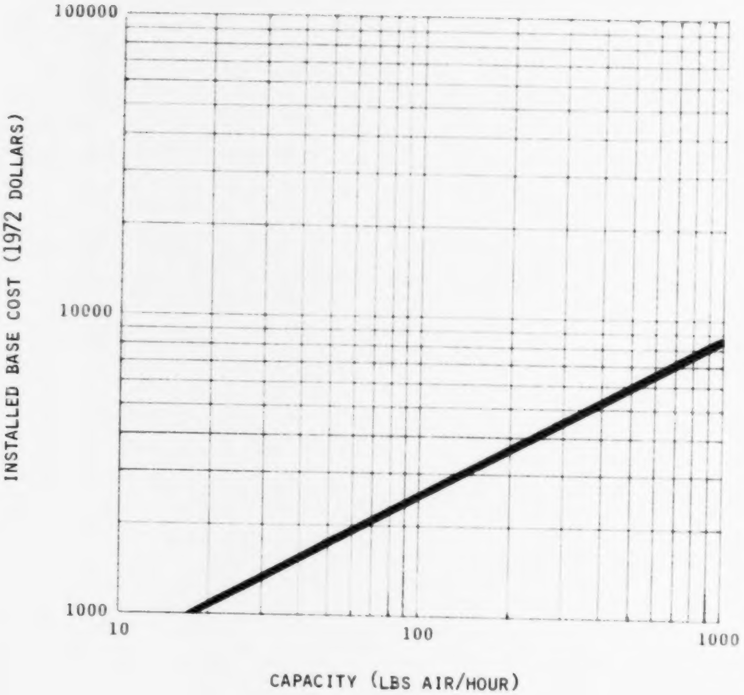
Electrical generators require between 0 and 5 operators per shift depending upon type, process application and size.

PROBABLE ANNUAL DEPRECIATION RATE

INDUSTRY GROUP	DEPRECIATION RATE (percent)	EXPECTED LIFETIME (years)
Heavy Chemical	0.036	28
Oil and Gas Refining	0.036	28
Resins and Polymers	0.036	28
Food and Beverage	0.036	28
Pulp and Paper	0.036	28
Mining	0.036	28

EJECTOR



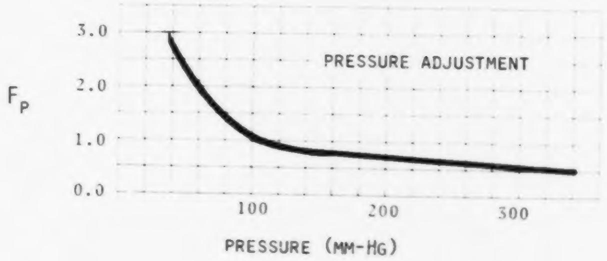


DESIGN ADJUSTMENT

Number of Stages	F_D
1	1.00
2	1.47
4	3.47
5	3.90

REGIONAL ADJUSTMENT

Region	F_R
1	1.000
2	1.084
3	0.987
4	1.046
5	1.081
6	1.031
7	1.081
8	1.033
9	1.081
10	1.041



Installed ejector cost includes purchased cost of ejector, handling and setting, piping, steel, insulation, and indirect costs (prime contractor engineering and construction overhead).

INSTALLED EJECTOR COST, $ = (INSTALLED BASE COST)$(F_D)(F_P)(F_R)$

ANNUAL MAINTENANCE

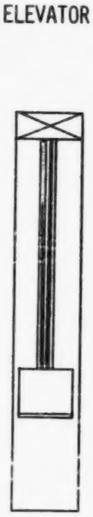
Annual maintenance will be approximately 1.6 percent of the installed ejector cost.

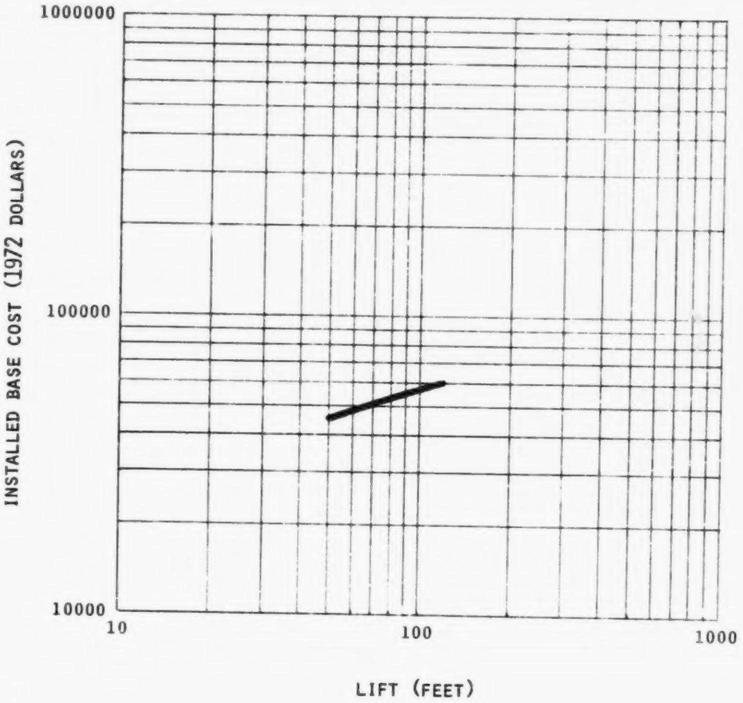
OPERATION COST

Ejectors require no operator attention.

PROBABLE ANNUAL DEPRECIATION RATE

INDUSTRY GROUP	DEPRECIATION RATE (percent)	EXPECTED LIFETIME (years)
Heavy Chemical	0.071-0.091	11-14
Oil and Gas Refining	0.063-0.071	14-16
Resins and Polymers	0.071-0.111	9-14
Food and Beverage	0.056-0.091	11-18
Pulp and Paper	0.063-0.100	10-16
Mining	0.063-0.100	10-18



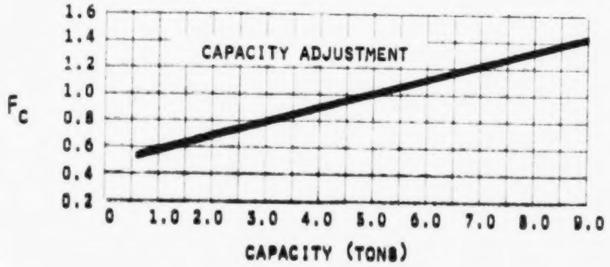


DESIGN ADJUSTMENT

Type	F_D
Freight	1.000
Passenger	1.506

REGIONAL ADJUSTMENT

Region	F_R
1	1.000
2	1.029
3	0.996
4	1.014
5	1.026
6	1.008
7	1.011
8	1.011
9	1.020
10	1.011



Installed elevator cost includes purchased cost of elevator, motor and drive, field erection by subcontractor, structural steel, subcontractors overhead and profit, indirect costs (prime contractor engineering and construction overhead).

INSTALLED ELEVATOR COST.$ = (INSTALLED BASE COST) $(F_D)(F_C)(F_R)$

ANNUAL MAINTENANCE

Annual maintenance will be approximately 1.6 percent of installed elevator cost.

OPERATION COST

Elevators require no operator attention.

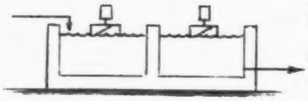
PROBABLE ANNUAL DEPRECIATION RATE

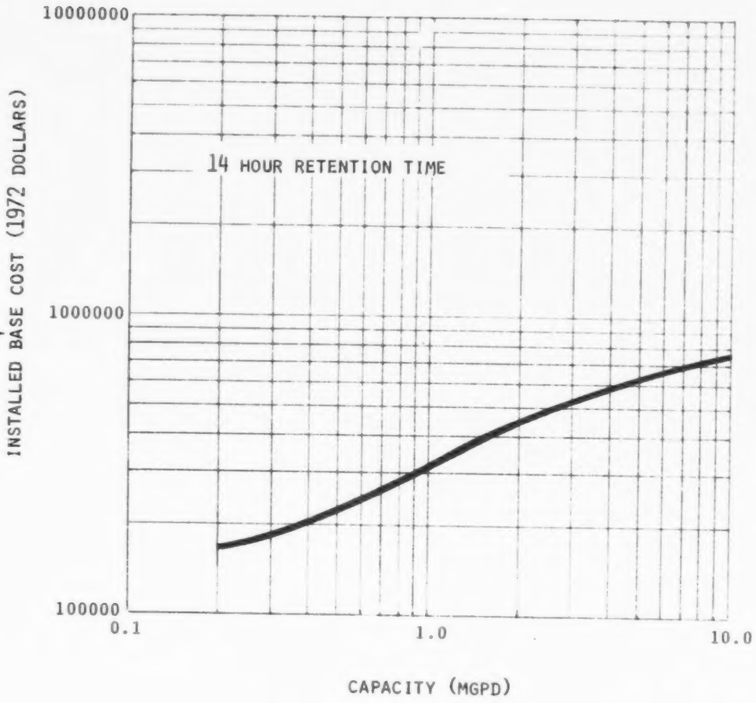
INDUSTRY GROUP	DEPRECIATION RATE (percent)	EXPECTED LIFETIME (years)
Heavy Chemical	0.016-0.022	45-60
Oil and Gas Refining	0.016-0.022	45-60
Resins and Polymers	0.016-0.022	45-60
Food and Beverage	0.016-0.022	45-60
Pulp and Paper	0.016-0.022	45-60
Mining	0.016-0.022	45-60

ES-1

EQUALIZATION SYSTEM

EQUALIZATION SYSTEM





REGIONAL ADJUSTMENT

Region	F_R
1	1.000
2	1.045
3	0.947
4	1.043
5	1.133
6	1.041
7	1.066
8	1.065
9	1.067
10	1.029

Installed equalization system cost includes **reinforced** concrete basin, variable speed centifugal pumps, floating aerators, piping, concrete, steel, instrumentation, electrical, paint, and indirect costs (prime contractor engineering and construction overhead)

INSTALLED EQUALIZATION SYSTEM COST,\$ = (INSTALLED BASE COST)(F_R)

ANNUAL MAINTENANCE

Annual maintenance will be approximately 0.25 to 0.75 percent of installed equalization system cost.

OPERATION COST

Equalization systems require no operator attention.

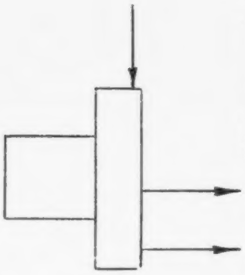
PROBABLE ANNUAL DEPRECIATION RATE

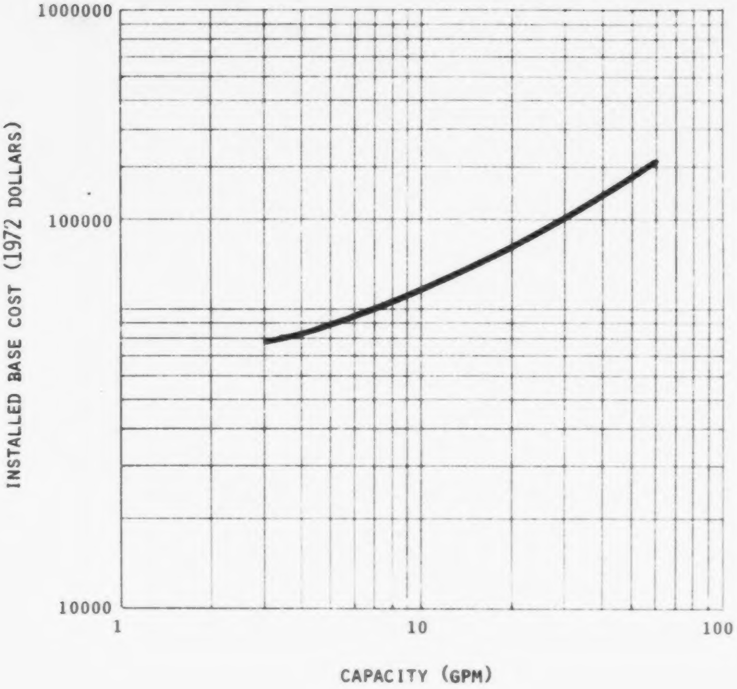
INDUSTRY GROUP	DEPRECIATION RATE (percent)	EXPECTED LIFETIME (years)
Heavy Chemical	0.016-0.040	25-60
Oil and Gas Refining	0.016-0.040	25-60
Resins and Polymers	0.016-0.040	25-60
Food and Beverage	0.016-0.040	25-60
Pulp and Paper	0.016-0.040	25-60
Mining	0.016-0.040	25-60

EX-1

EXTRACTOR

EXTRACTOR





REGIONAL ADJUSTMENT

Region	F_R
1	1.000
2	1.045
3	0.947
4	1.043
5	1.133
6	1.041
7	1.066
8	1.065
9	1.067
10	1.029

Installed extractor cost includes purchased cost of continuous centrifugal extractor, motor and drive, handling and setting, piping, concrete, steel, instrumentation, electrical, insulation, paint, and indirect costs (prime contractor engineering and construction overhead).

INSTALLED EXTRACTOR COST,$ = (INSTALLED BASE COST) (F_R)

ANNUAL MAINTENANCE

Annual maintenance will be approximately 2 percent of the installed extractor cost and will depend upon cycle time, operating hours per year and process conditions.

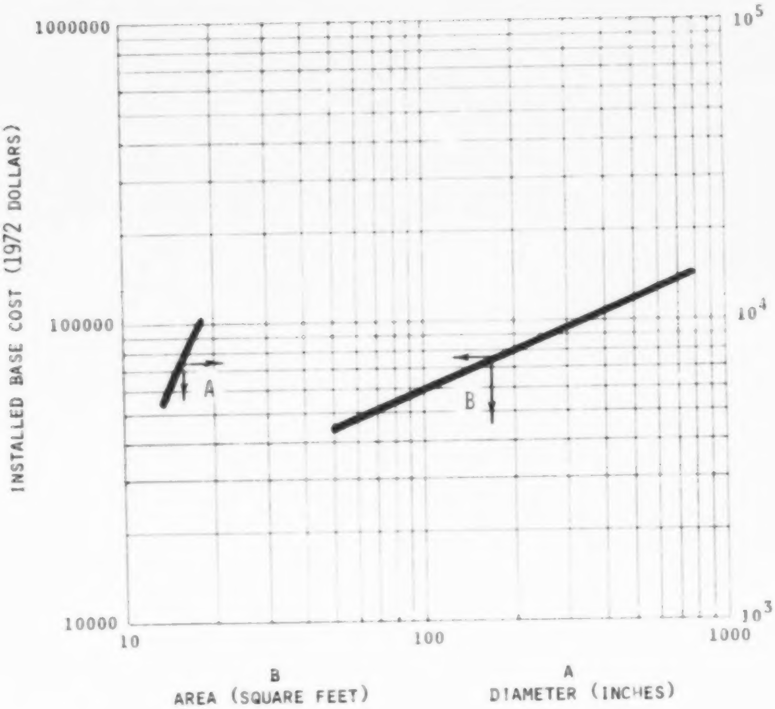
OPERATION COST

Extractors require approximately 0.25 operators per shift.

PROBABLE ANNUAL DEPRECIATION RATE

INDUSTRY GROUP	DEPRECIATION RATE (percent)	EXPECTED LIFETIME (years)
Heavy Chemical	0.05-0.091	11-20
Oil and Gas Refining	0.063-0.071	14-16
Resins and Polymers	0.071-0.111	9-14
Food and Beverage	0.056-0.091	11-18
Pulp and Paper	0.063-0.100	10-16
Mining	0.063-0.100	10-18

FILTER



DESIGN ADJUSTMENT

Type	Curve	F_D
Sewage	B	1.00
Rotary Drum	B	1.36
Rotary Disk	B	1.45
Plate and Frame	B	0.25
Wet Leaf	B	0.30
Dry Leaf	B	0.36
Sparkler	A	1.00

PLATE AND FRAME MATERIAL ADJUSTMENT

Material	F_M
CS	1.00
Pb	2.15
Fine	0.82
Al	1.68
Bronze	2.91
SS	5.53

REGIONAL ADJUSTMENT

Region	F_R
1	1.000
2	1.021
3	0.930
4	1.038
5	1.151
6	1.044
7	1.062
8	1.077
9	1.061
10	1.021

Installed filter cost includes purchased cost of filter, (motor and drive when applicable), auxiliaries, handling and setting, piping and ductwork, concrete, steel, instrumentation, electrical, insulation, paint, and indirect costs (prime contractor engineering and construction overhead).

INSTALLED FILTER COST,\$ = (INSTALLED BASE COST)$(F_D)(F_M)(F_R)$

ANNUAL MAINTENANCE

Annual maintenance will vary from 3.39 - 5.62 percent of installed filter cost and will depend upon process thruput, percent solids, particle size, temperature and pressure, and cycle time.

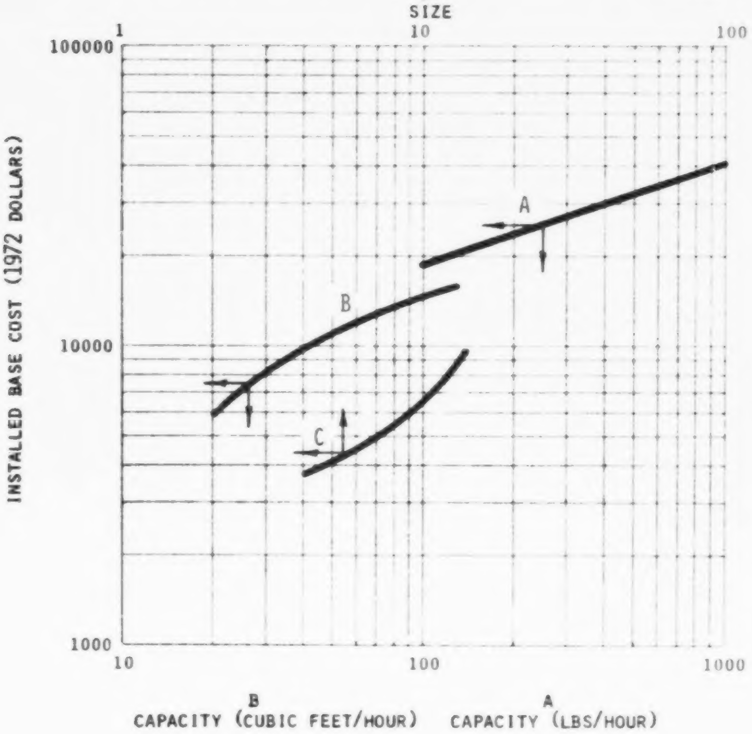
OPERATION COST

Filters require between 0.25 and 0.5 operators per shift.

PROBABLE ANNUAL DEPRECIATION RATE

INDUSTRY GROUP	DEPRECIATION RATE (percent)	EXPECTED LIFETIME (years)
Heavy Chemical	0.05-0.091	11-20
Oil and Gas Refining	0.063-0.071	14-16
Resins and Polymers	0.071-0.111	9-14
Food and Beverage	0.056-0.091	11-18
Pulp and Paper	0.063-0.100	10-16
Mining	0.063-0.100	10-18

FEEDER


C
SIZE
1
10
100
100000
10000
1000
INSTALLED BASE COST (1972 DOLLARS)
A
B
C
10
100
1000
B
CAPACITY (CUBIC FEET/HOUR)
A
CAPACITY (LBS/HOUR)

DESIGN ADJUSTMENT

Type	Curve	F_D
Chamber	B	1.000
Belt	B	1.475
Weight Loss	A	1.000
Rotary	C	1.000

REGIONAL ADJUSTMENT

Region	F_R
1	1.000
2	1.036
3	0.959
4	1.027
5	1.099
6	1.027
7	1.043
8	1.044
9	1.050
10	1.019

Installed feeder cost includes purchased cost of feeder, motor and drive, handling and setting, piping and ductwork, concrete, instrumentation, electrical, paint, and indirect costs (prime contractor engineering and construction overhead).

INSTALLED FEEDER COST,\$ = (INSTALLED BASE COST)$(F_D)(F_R)$

ANNUAL MAINTENANCE

Annual maintenance will be approximately 3 percent of installed feeder cost.

OPERATION COST

Feeders require no operator attention.

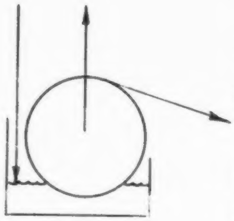
PROBABLE ANNUAL DEPRECIATION RATE

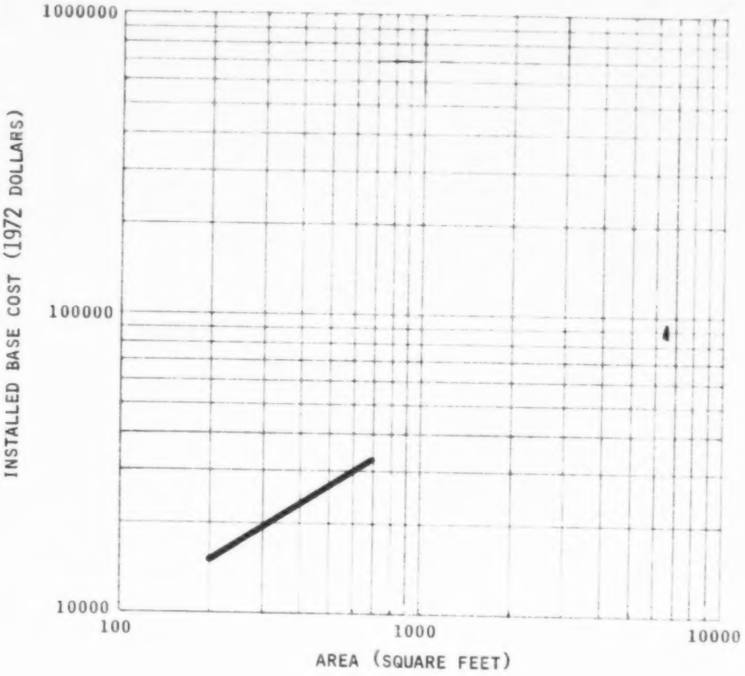
INDUSTRY GROUP	DEPRECIATION RATE (percent)	EXPECTED LIFETIME (years)
Heavy Chemical	0.05-0.091	11-20
Oil and Gas Refining	0.063-0.071	14-16
Resins and Polymers	0.071-0.111	9-14
Food and Beverage	0.056-0.091	11-18
Pulp and Paper	0.063-0.100	10-16
Mining	0.063-0.100	10-18

FL-1

FLAKER

FLAKER





REGIONAL ADJUSTMENT

Region	F_R
1	1.000
2	1.050
3	0.965
4	1.038
5	1.104
6	1.034
7	1.059
8	1.051
9	1.059
10	1.030

Installed flaker cost includes purchased cost of flaker, motor and drive, accessories, handling and setting, piping and ductwork, concrete, steel, instrumentation, electrical, insulation, paint, and indirect costs (prime contractor engineering and construction overhead).

INSTALLED FLAKER COST,\$ = (INSTALLED BASE COST)(F_R)

ANNUAL MAINTENANCE

Annual maintenance will be approximately 2.75 percent of installed **flaker** cost.

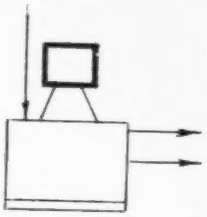
OPERATION COST

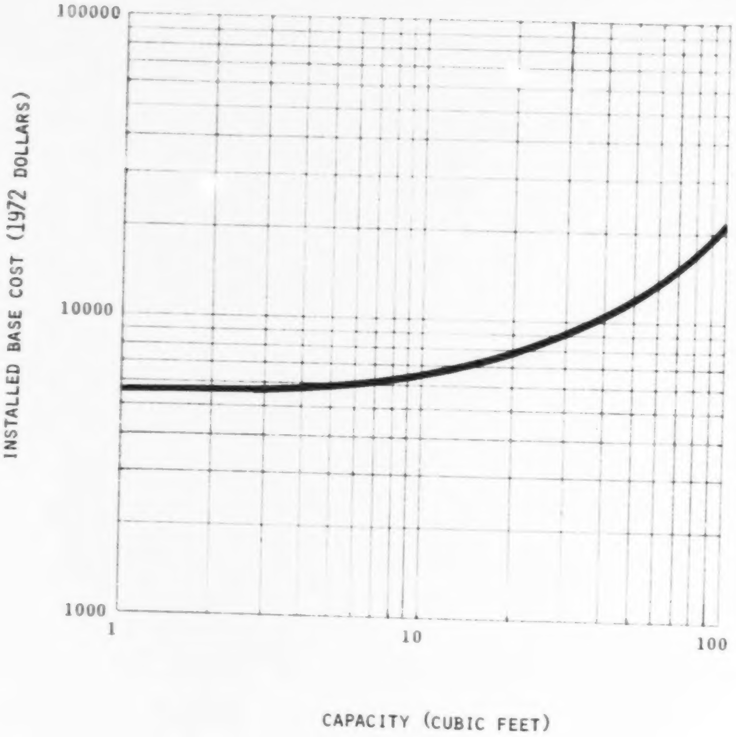
Flakers require approximately 0.25 operators per shift.

PROBABLE ANNUAL DEPRECIATION RATE

INDUSTRY GROUP	DEPRECIATION RATE (percent)	EXPECTED LIFETIME (years)
Heavy Chemical	0.05-0.091	11-20
Oil and Gas Refining	0.063-0.071	14-16
Resins and Polymers	0.071-0.111	9-14
Food and Beverage	0.056-0.091	11-18
Pulp and Paper	0.063-0.100	10-16
Mining	0.063-0.100	10-18

FLOATATION MACHINE





REGIONAL ADJUSTMENT

Region	F_R
1	1.000
2	1.050
3	0.945
4	1.044
5	1.139
6	1.043
7	1.071
8	1.068
9	1.074
10	1.031

Installed floatation machine cost includes purchased cost of floatation machine, motor and drive, handling and setting, piping, concrete, steel, instrumentation, electrical, insulation, paint, and indirect costs (prime contractor engineering and construction overhead).

INSTALLED FLOATATION MACHINE COST.$ = (INSTALLED BASE COST)(F_R)

ANNUAL MAINTENANCE

Annual maintenance will be approximately 2 percent of installed floatation machine cost.

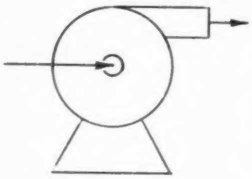
OPERATION COST

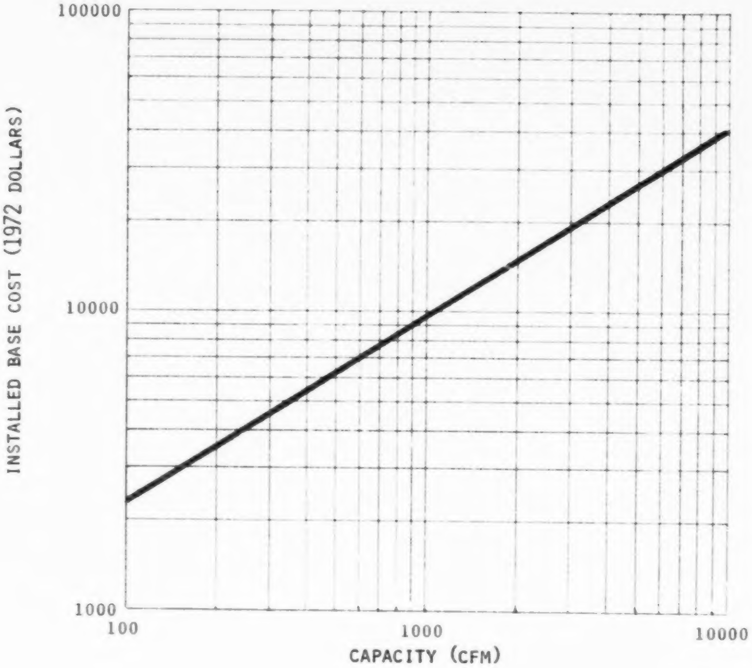
Floatation machines require approximately 0.25 operators per shift.

PROBABLE ANNUAL DEPRECIATION RATE

INDUSTRY GROUP	DEPRECIATION RATE (percent)	EXPECTED LIFETIME (years)
Heavy Chemical	0.056-0.100	10-18
Oil and Gas Refining	0.056-0.100	10-18
Resins and Polymers	0.056-0.100	10-18
Food and Beverage	0.056-0.100	10-18
Pulp and Paper	0.056-0.100	10-18
Mining	0.056-0.100	10-18

FAN



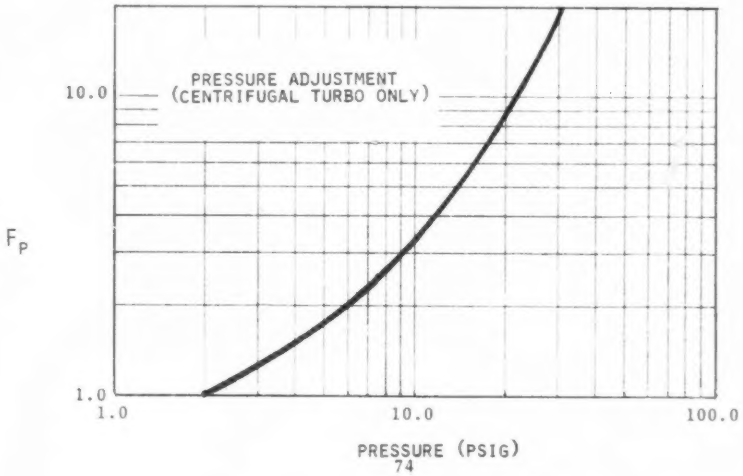


DESIGN ADJUSTMENT

Type	F_D	Pressure Range	F_P
Centrifugal Turbo	1.000	1-30 psig	1.0 - 20.0
Centrifugal Compressor	32.110	1000 psig	1.0
Centrifugal	0.106	--	1.0
Propeller	0.063	--	1.0
Rotary Blower	1.692	10 psig	1.0
Vane Axial	0.134	--	1.0

REGIONAL ADJUSTMENT

Region	F_R
1	1.000
2	1.047
3	0.951
4	1.036
5	1.125
6	1.035
7	1.054
8	1.054
9	1.066
10	1.025



Installed fan cost includes purchased cost of fan, motor and drive, handling and setting, piping and ductwork, concrete, steel, instrumentation, electrical, insulation, paint, and indirect costs (prime contractor engineering and construction overhead).

INSTALLED FAN COST,\$ = (INSTALLED BASE COST) $(F_D)(F_P)(F_R)$

ANNUAL MAINTENANCE

Annual maintenance will vary from 1.27 - 1.36 percent of installed fan cost.

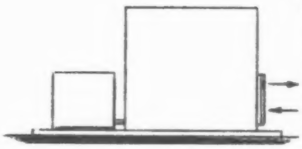
OPERATION COST

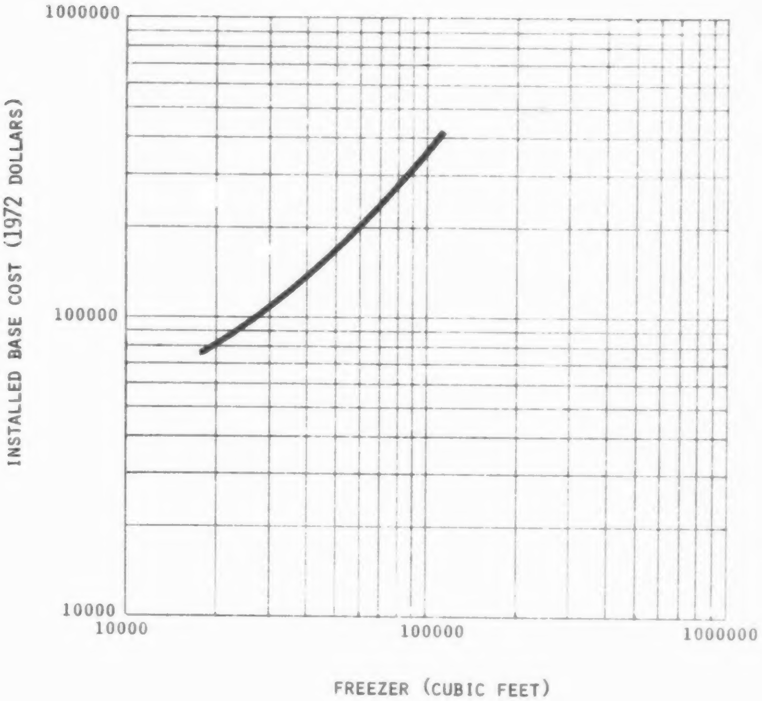
Fans require no operator attention.

PROBABLE ANNUAL DEPRECIATION RATE

INDUSTRY GROUP	DEPRECIATION RATE (percent)	EXPECTED LIFETIME (years)
Heavy Chemical	0.05-0.091	11-20
Oil and Gas Refining	0.063-0.071	14-16
Resins and Polymers	0.071-0.111	9-14
Food and Beverage	0.056-0.091	11-18
Pulp and Paper	0.063-0.100	10-16
Mining	0.063-0.100	10-18

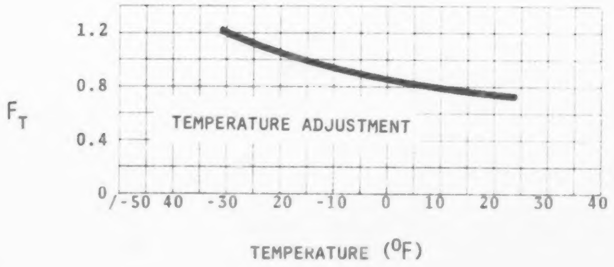
FREEZER





REGIONAL ADJUSTMENT

Region	F_R
1	1.000
2	1.067
3	0.973
4	1.036
5	1.091
6	1.030
7	1.061
8	1.035
9	1.067
10	1.031



Installed freezer cost includes purchased cost of freezer, refrigeration equipment, structure, field erection by subcontractor, subcontractor overhead and profit, piping, ductwork, indirect costs (prime contractor engineering and construction overhead).

INSTALLED FREEZER COST,\$ = (INSTALLED BASE COST) $(F_T)(F_R)$

ANNUAL MAINTENANCE

Annual maintenance will be approximately 5 percent of installed freezer cost.

OPERATION COST

Freezers require no operator attention.

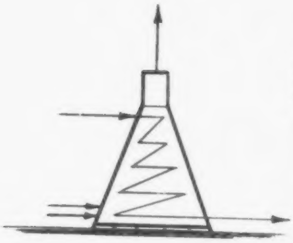
PROBABLE ANNUAL DEPRECIATION RATE

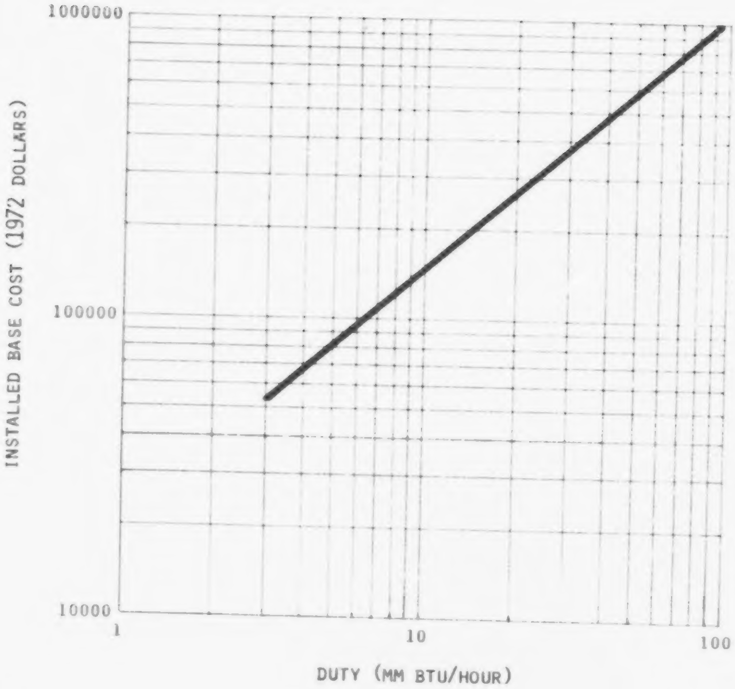
INDUSTRY GROUP	DEPRECIATION RATE (percent)	EXPECTED LIFETIME (years)
Heavy Chemical	0.056-0.083	12-18
Oil and Gas Refining	0.056-0.083	12-18
Resins and Polymers	0.056-0.083	12-18
Food and Beverage	0.056-0.083	12-18
Pulp and Paper	0.056-0.083	12-18
Mining	0.056-0.083	12-18

FU-1

FURNACE

FURNACE





DESIGN ADJUSTMENT

Type	F_D	Pressure (PSIG)
Heater	1.000	3000
Box	0.890	1000
Pyrolysis	1.160	3000
Reformer	1.250	3000
Vertical	0.670	1000

REGIONAL ADJUSTMENT

Region	F_R
1	1.000
2	1.041
3	0.989
4	1.027
5	1.053
6	1.020
7	1.044
8	1.026
9	1.043
10	1.022

MATERIAL ADJUSTMENT

Material	F_M
CS	1.000
SS	1.264
Chrome-Moly	1.119

Installed furnace cost includes purchased cost of furnace, field erection by subcontractor, blowers, motors and drivers, piping, concrete, instrumentation, electrical, insulation, paint, and indirect costs (prime contractor engineering and construction overhead).

INSTALLED FURNACE COST,\$ = (INSTALLED BASE COST) $(F_D)(F_M)(F_R)$

ANNUAL MAINTENANCE

Annual maintenance will be approximately 1.7 percent of installed furnace cost.

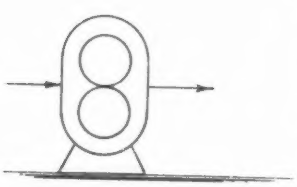
OPERATION COST

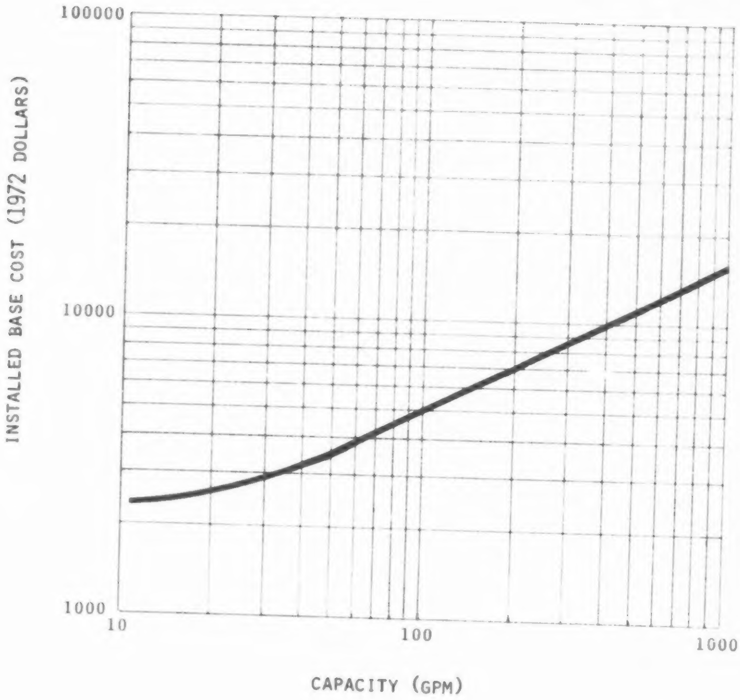
Furnaces require approximately 0.25 operators per shift.

PROBABLE ANNUAL DEPRECIATION RATE

INDUSTRY GROUP	DEPRECIATION RATE (percent)	EXPECTED LIFETIME (years)
Heavy Chemical	0.071-0.091	11-14
Oil and Gas Refining	0.063-0.071	14-16
Resins and Polymers	0.071-0.111	9-14
Food and Beverage	0.056-0.083	12-18
Pulp and Paper	0.063	16
Mining	0.100	10

GEAR PUMP





DESIGN ADJUSTMENT

Type	F_D
Canned Rotor	1.000
Mechanical Seal (Glass Lined CS only)	1.351

REGIONAL ADJUSTMENT

Region	F_R
1	1.000
2	1.062
3	0.982
4	1.033
5	1.073
6	1.025
7	1.055
8	1.026
9	1.064
10	1.031

MATERIAL ADJUSTMENT

Material	F_M
CS	0.000
SS	0.175
Bronze	0.287

Installed gear pump cost includes purchased cost of gear pump, base plate, coupling, motor and drive, handling and setting, piping, concrete, instrumentation, electrical, insulation, paint, and indirect costs (prime contractor engineering and construction overhead).

INSTALLED GEAR PUMP COST,$ = (INSTALLED BASE COST) $(F_D + F_M)(F_R)$

ANNUAL MAINTENANCE

Annual maintenance will vary from 1.5 - 4.6 percent of installed gear pump cost and will depend upon cycle time, operating hours per year, fluid abrasiveness, temperature and pressure.

OPERATION COST

Gear pumps require no operator attention.

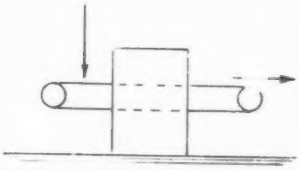
PROBABLE ANNUAL DEPRECIATION RATE

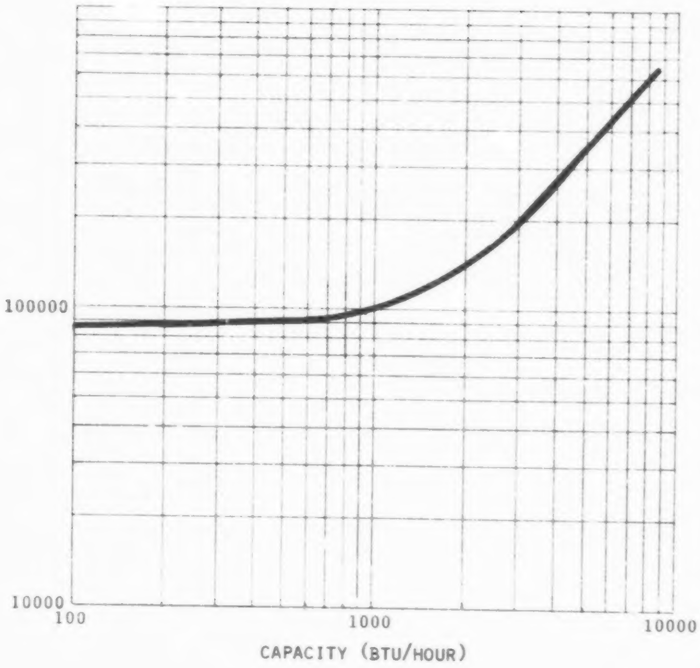
INDUSTRY GROUP	DEPRECIATION RATE (percent)	EXPECTED LIFETIME (years)
Heavy Chemical	0.05-0.091	11-20
Oil and Gas Refining	0.063-0.071	14-16
Resins and Polymers	0.071-0.111	9-14
Food and Beverage	0.056-0.091	11-18
Pulp and Paper	0.063-0.100	10-16
Mining	0.063-0.100	10-18

HAB-1

HOT AIR BLANCHER

HOT AIR BLANCHER





REGIONAL ADJUSTMENT

Region	F_R
1	1.000
2	1.037
3	1.959
4	1.027
5	1.100
6	1.027
7	1.042
8	1.045
9	1.050
10	1.019

Installed hot air blancher cost includes purchased cost of hot air blanching unit, conveyor belt, driver, gas fired heater, blower, handling and setting, piping, and ductwork, concrete, steel, instrumentation, electrical, insulation, paint, and indirect costs (prime contractor engineering and construction overhead).

INSTALLED HOT AIR BLANCHER COST,\$ = (INSTALLED BASE COST)(F_R)

ANNUAL MAINTENANCE

Annual maintenance will vary from 0.32 to 6.85 percent of installed hot air blancher cost and will be primarily dependent upon product characteristics and cycling.

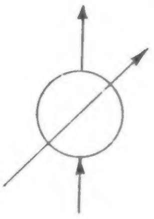
OPERATION COST

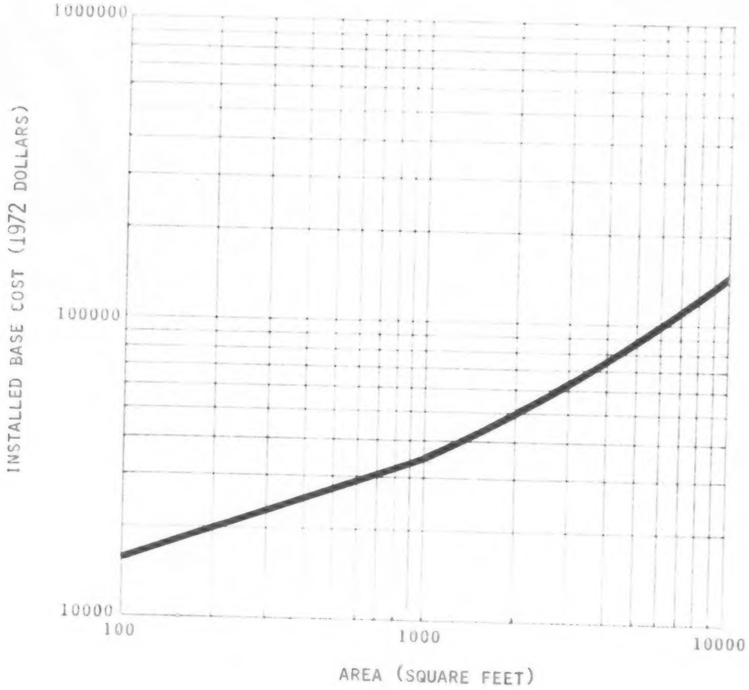
Hot air blanchers require between 0.05 and 0.25 operators per shift.

PROBABLE ANNUAL DEPRECIATION RATE

INDUSTRY GROUP	DEPRECIATION RATE (percent)	EXPECTED LIFETIME (years)
Heavy Chemical	0.050-0.071	14-20
Oil and Gas Refining	0.063-0.071	14-16
Resins and Polymers	0.071-0.111	9-14
Food and Beverage	0.056-0.091	11-18
Pulp and Paper	0.063-0.100	10-16
Mining	0.063-0.100	10-18

HEAT EXCHANGER



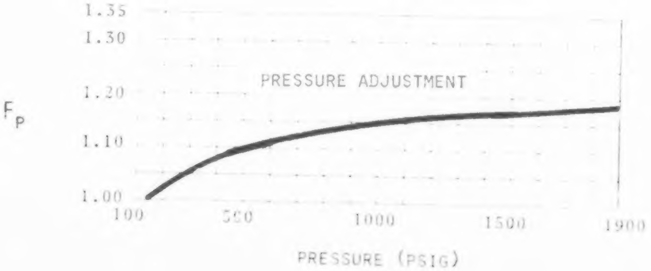


DESIGN ADJUSTMENT

Design Type	F_D
Fixed Tube Sheet	1.000
U-Tube Reboiler	1.010
Kettle Reboiler	1.350
Steam Coil Tank Heater	0.131
Jacketed Pipe	1.561
Thermascrew (Rietz) Single Screw	1.260
Shell and Tube Calandria	2.470
Spiral Plate	1.060
Thermascrew (Rietz) Twin Screw	2.170
Suction Heater	0.638
Spiral Tube	0.805
Plate Coil - Header Type	0.977
Plate Coil - Serpentine Type	0.775
Cascade Cooler	0.858
Drip Cooler	2.940
Fin Tube	0.966
Floating Head	0.622
U-Tube	0.542
Shell & Tube	1.000
Waste Heat Boiler	2.180

REGIONAL ADJUSTMENT

Region	F_R
1	1.000
2	1.074
3	0.982
4	1.038
5	1.087
6	1.026
7	1.069
8	1.027
9	1.078
10	1.037



MATERIAL ADJUSTMENT

Tube Material	Shell Material	1000 ft^2 F_M	10000 ft^2 F_M
CS	CS	1.00	1.00
SS304	CS	1.14	1.24
SS304	SS304	1.22	1.43
SS316	SS316	1.34	1.67
Ni	CS	1.66	1.82
Ni	Ni	2.01	3.14
Ti	CS	1.71	2.62
Ti	Ti	2.04	3.10
Al	CS	1.04	1.18
Al	Al	1.12	1.22
Brass	CS	1.30	1.41
Brass	Brass	1.44	1.93
Cu	CS	1.38	1.66
Cu	Cu	1.54	1.93
Monel	CS	1.53	2.03
Monel	Monel	1.83	2.57
Moly	CS	2.31	3.02
Moly	Moly	2.96	4.76

Installed heat exchanger cost includes purchased cost of heat exchanger, handling and setting, piping, concrete, steel, instrumentation, electrical, insulation, paint, and indirect costs (prime contractor engineering and construction overhead).

INSTALLED HEAT EXCHANGER COST,\$ = (INSTALLED BASE COST) $(F_D)(F_P)(F_M)(F_R)$

ANNUAL MAINTENANCE

Annual maintenance will vary from 1 to 2.3 percent of installed heat exchanger cost and will depend upon fouling characteristics of fluid, temperature and pressure, and fluid velocity.

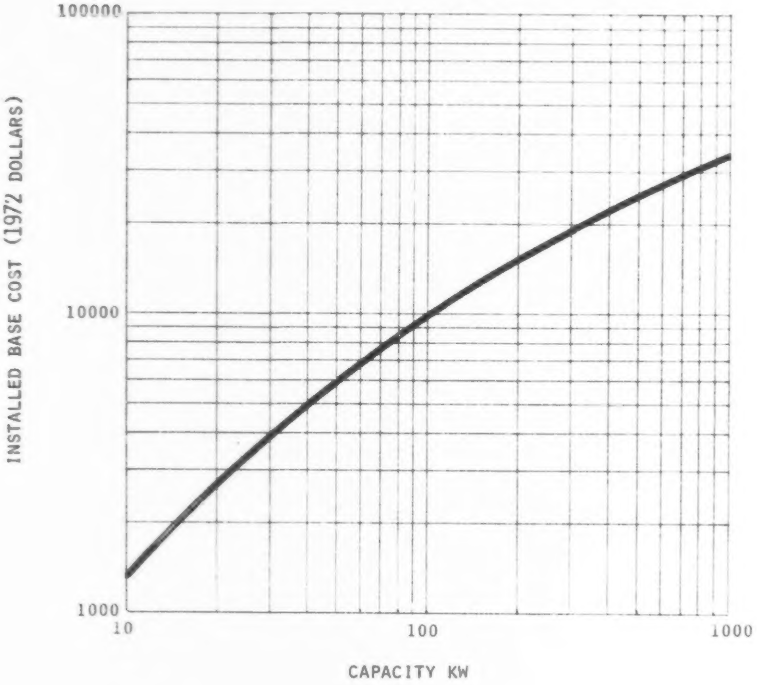
OPERATION COST

Heat exchangers require no operator attention.

PROBABLE ANNUAL DEPRECIATION RATE

INDUSTRY GROUP	DEPRECIATION RATE (percent)	EXPECTED LIFETIME (years)
Heavy Chemical	0.05-0.091	11-20
Oil and Gas Refining	0.063-0.071	14-16
Resins and Polymers	0.071-0.111	9-14
Food and Beverage	0.056-0.091	11-18
Pulp and Paper	0.063-0.100	10-16
Mining	0.063-0.100	10-18

ELECTRICAL HEATERS



REGIONAL ADJUSTMENT

Region	F_R
1	1.000
2	1.073
3	0.978
4	1.036
5	1.083
6	1.029
7	1.071
8	1.027
9	1.074
10	1.035

Installed electrical heater cost includes purchased cost of electrical heater, handling and setting, piping, concrete, steel, instrumentation, electrical, insulation, paint, and indirect costs (prime contractor engineering and construction overhead).

INSTALLED ELECTRICAL HEATER COST,\$ = (INSTALLED BASE COST) (F_R)

ANNUAL MAINTENANCE

Annual maintenance will vary from 1 to 3 percent of installed electrical heater cost.

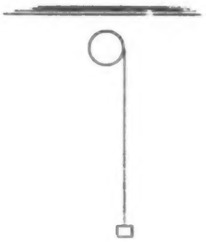
OPERATION COST

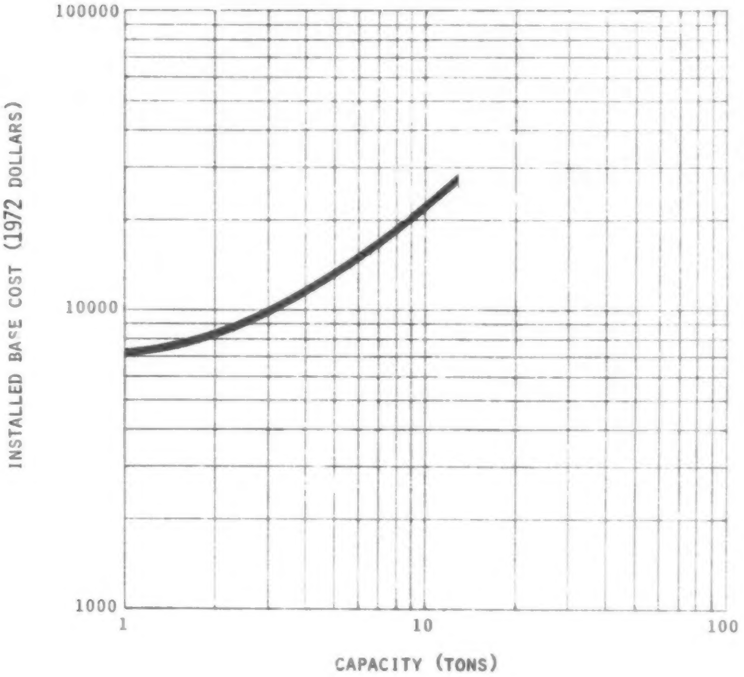
Electrical heaters require no operator attention.

PROBABLE ANNUAL DEPRECIATION RATE

INDUSTRY GROUP	DEPRECIATION RATE (percent)	EXPECTED LIFETIME (years)
Heavy Chemical	0.05-0.091	11-20
Oil and Gas Refining	0.063-0.071	14-16
Resins and Polymers	0.071-0.111	9-14
Food and Beverage	0.056-0.091	11-18
Pulp and Paper	0.063-0.100	10-16
Mining	0.063-0.100	10-18

HOIST





DESIGN ADJUSTMENT

Type	F_D
Hoist	1.000
Plain Trolly	0.115
Gear Trolly	0.325
No Trolly	0.089
1 Speed	0.510
5 Speed	0.634

REGIONAL ADJUSTMENT

Region	F_R
1	1.000
2	1.040
3	0.995
4	1.022
5	1.040
6	1.036
7	1.026
8	1.017
9	1.031
10	1.018

Installed hoist cost includes purchased cost of hoist, field erection, steel, electrical, paint, and indirect costs (prime contractor engineering and construction overhead).

INSTALLED HOIST COST.$ = (INSTALLED BASE COST)$(F_D)(F_R)$

ANNUAL MAINTENANCE

Annual maintenance will be approximately 1.28 percent of installed hoist cost.

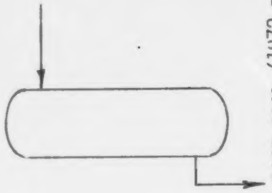
OPERATION COST

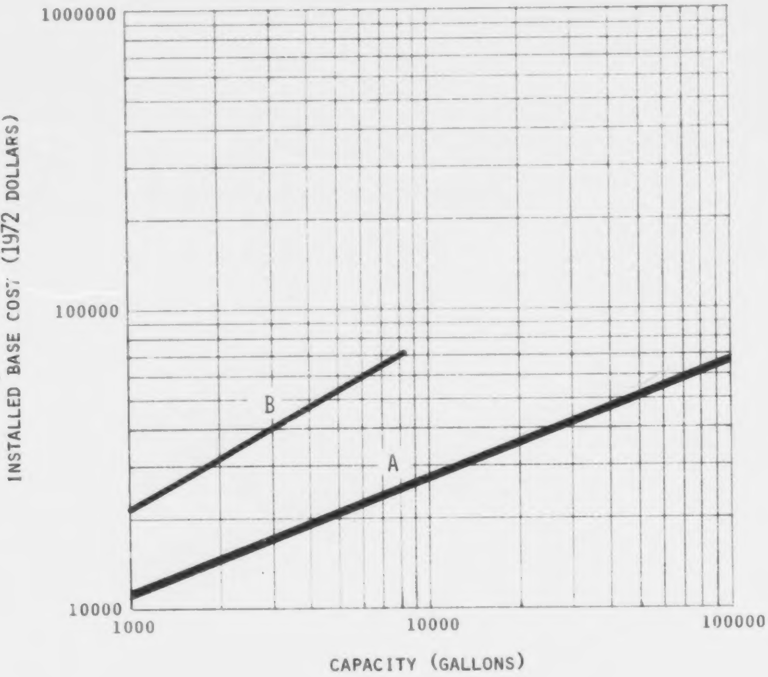
Hoists require no operator attention.

PROBABLE ANNUAL DEPRECIATION RATE

INDUSTRY GROUP	DEPRECIATION RATE (percent)	EXPECTED LIFETIME (years)
Heavy Chemical	0.05-0.091	11-20
Oil and Gas Refining	0.063-0.071	14-16
Resins and Polymers	0.071-0.111	9-14
Food and Beverage	0.056-0.091	11-18
Pulp and Paper	0.063-0.100	10-16
Mining	0.063-0.100	10-18

HORIZONTAL TANK





DESIGN ADJUSTMENT

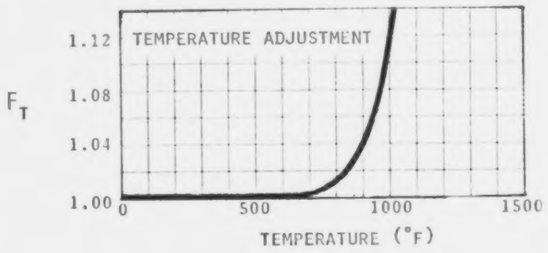
Type	F_D	Curve
Cylindrical	1.000	A
Vacuum Receiver	1.000	B
Jacketed Vacuum Receiver	2.830	B

REGIONAL ADJUSTMENT

Region	F_R
1	1.000
2	1.062
3	0.986
4	1.032
5	1.071
6	1.026
7	1.062
8	1.026
9	1.069
10	1.031

MATERIAL ADJUSTMENT

Material	F_M
CS	1.000
Al	1.361
Ti	1.449
Monel	1.280
Ni	1.342
Glass Lined CS	1.879
Cu	1.237
Moly	1.599
SS304	1.068
SS316	1.112
A 204 CS	1.006



Installed horizontal tank cost includes purchased cost of horizontal tank, handling and setting, piping, concrete, instrumentation, electrical, insulation, paint, and indirect costs (prime contractor engineering and construction overhead).

INSTALLED HORIZONTAL TANK COST, $ = (INSTALLED BASE COST)$(F_M)(F_P)(F_T)(F_R)$ (F_D)

ANNUAL MAINTENANCE

Annual maintenance will vary from 0.94 - 2.10 percent of installed horizontal tank cost and will depend upon corrosiveness of fluid, temperature, and pressure.

OPERATION COST

Horizontal tanks require no operator attention.

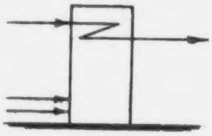
PROBABLE ANNUAL DEPRECIATION RATE

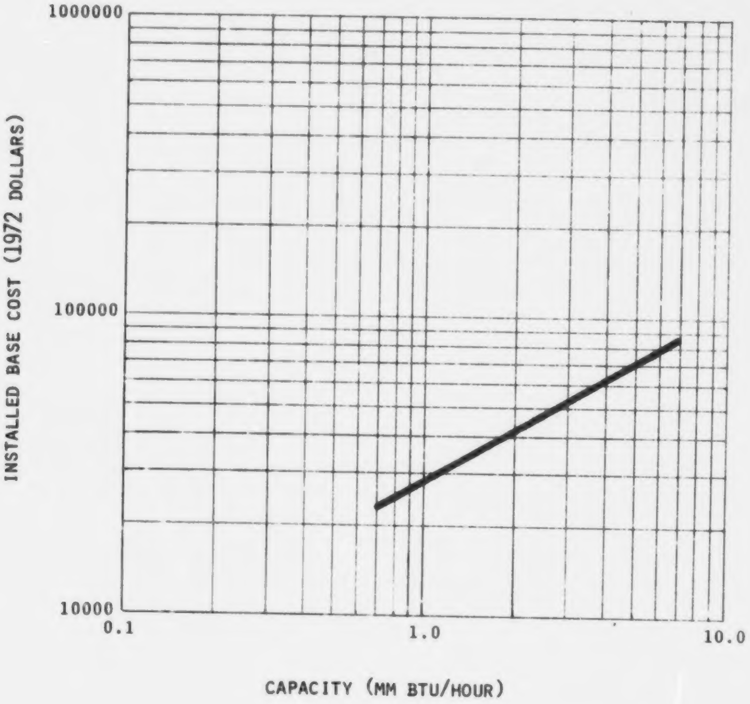
INDUSTRY GROUP	DEPRECIATION RATE (percent)	EXPECTED LIFETIME (years)
Heavy Chemical	0.050-0.091	11-20
Oil and Gas Refining	0.045	22
Resins and Polymers	0.045	22
Food and Beverage	0.045	22
Pulp and Paper	0.045	22
Mining	0.045	22

HU-1

HEATING UNIT

HEATING UNIT





REGIONAL ADJUSTMENT

Region	F_R
1	1.000
2	1.044
3	0.979
4	1.030
5	1.069
6	1.015
7	1.051
8	1.034
9	1.051
10	1.024

Installed heating unit cost includes purchased cost of heating unit, accessories, field erection by subcontractor, subcontractor's overhead and profit, piping, concrete, instrumentation, electrical, insulation, paint, and indirect costs (prime contractor engineering and construction overhead).

INSTALLED HEATING UNIT COST,\$ = (INSTALLED BASE COST)(F_R)

ANNUAL MAINTENANCE

Annual maintenance will vary from 2.6 - 2.9 percent of installed heating unit cost.

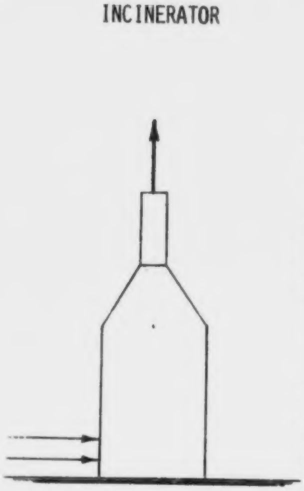
OPERATION COST

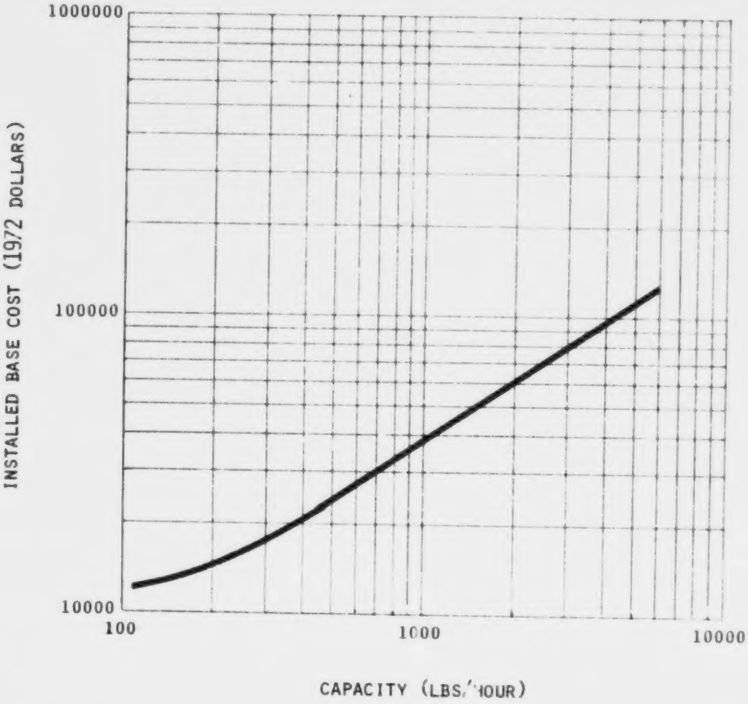
Heating units require approximately 0.25 operators per shift.

PROBABLE ANNUAL DEPRECIATION RATE

INDUSTRY GROUP	DEPRECIATION RATE (percent)	EXPECTED LIFETIME (years)
Heavy Chemical	0.071-0.091	11-14
Oil and Gas Refining	0.063-0.071	14-16
Resins and Polymers	0.071-0.111	9-14
Food and Beverage	0.056-0.083	12-18
Pulp and Paper	0.063	16
Mining	0.100	10

INCINERATOR


INCINERATOR



REGIONAL ADJUSTMENT

Region	F_R
1	1.000
2	1.005
3	0.923
4	1.033
5	1.569
6	1.043
7	1.055
8	1.082
9	1.056
10	1.014

Installed incinerator cost includes purchased cost of incinerator, field erection, piping, concrete, steel, instrumentation, insulation, paint, and indirect costs (prime contractor engineering and construction overhead).

INSTALLED INCINERATOR COST.\$ = (INSTALLED BASE COST)(F_R)

ANNUAL MAINTENANCE

Annual maintenance will be approximately 1.4 percent of installed incinerator cost.

OPERATION COST

Incinerators require no operator attention.

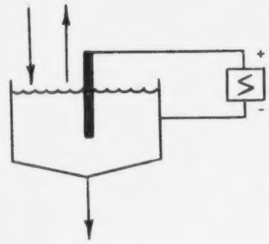
PROBABLE ANNUAL DEPRECIATION RATE

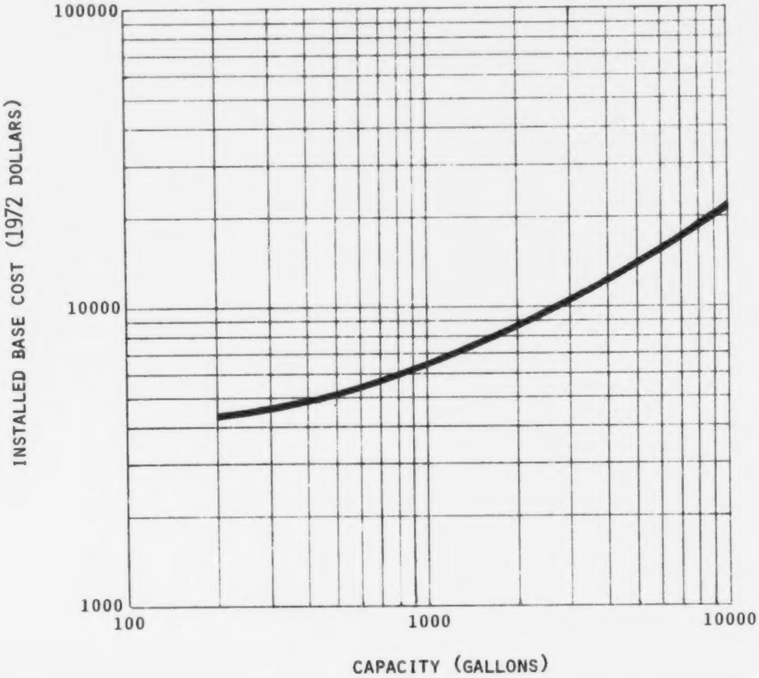
INDUSTRY GROUP	DEPRECIATION RATE (percent)	EXPECTED LIFETIME (years)
Heavy Chemical	0.05-0.091	11-20
Oil and Gas Refining	0.063-0.071	14-16
Resins and Polymers	0.071-0.111	9-14
Food and Beverage	0.056-0.091	11-18
Pulp and Paper	0.063-0.100	10-16
Mining	0.063-0.100	10-18

IVS-1

IMPRESSED VOLTAGE SYSTEM

IMPRESSED VOLTAGE SYSTEM





REGIONAL ADJUSTMENT

Region	F_R
1	1.000
2	1.062
3	0.986
4	0.992
5	1.326
6	0.966
7	1.273
8	1.073
9	1.219
10	1.082

Installed impressed voltage system cost includes purchased cost of tank, anodes, rectifier, handling and setting, piping, concrete, steel, instrumentation, electrical, paint, and indirect costs (prime contractor engineering and construction overhead).

INSTALLED IMPRESSED VOLTAGE SYSTEM COST,\$ = (INSTALLED BASE COST)(F_R)

ANNUAL MAINTENANCE

Annual maintenance will be approximately 1 to 3 percent of installed impressed voltage system cost.

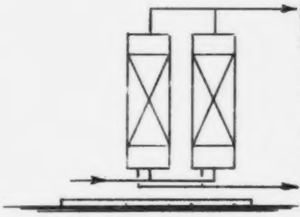
OPERATION COST

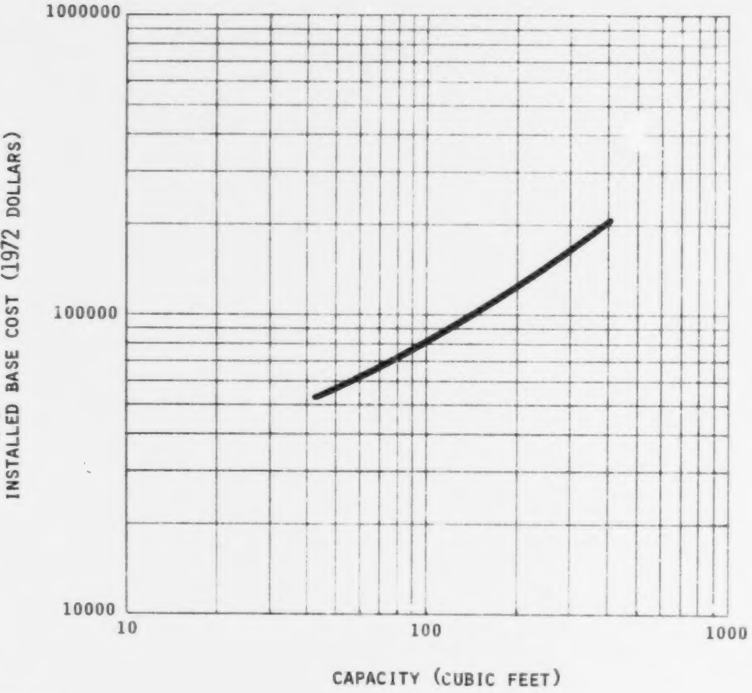
Impressed voltage systems require no operator attention.

PROBABLE ANNUAL DEPRECIATION RATE

INDUSTRY GROUP	DEPRECIATION RATE (percent)	EXPECTED LIFETIME (years)
Heavy Chemical	0.050-0.091	11-20
Oil and Gas Refining	0.045	22
Resins and Polymers	0.045	22
Food and Beverage	0.045	22
Pulp and Paper	0.045	22
Mining	0.045	22

ION EXCHANGER





DESIGN ADJUSTMENT

Type	F_D
Anion	1.000
Hydrogen Cation	0.776
Sodium Cation	0.435

REGIONAL ADJUSTMENT

Region	F_R
1	1.000
2	1.066
3	0.980
4	1.041
5	1.083
6	1.029
7	1.073
8	1.031
9	1.074
10	1.034

Installed ion exchanger cost includes purchased cost of ion exchanger, auxiliaries, ion exchange resin, handling and setting, piping, concrete, steel, instrumentation, electrical, insulation, paint, and indirect costs (prime contractor engineering and construction overhead).

INSTALLED ION EXCHANGER COST.\$ = (INSTALLED BASE COST)$(F_D)(F_R)$

ANNUAL MAINTENANCE

Annual maintenance will be approximately 3 percent of installed ion exchanger cost and will depend upon cycle time, and fluid characteristics, packing, loading, temperature and pressure.

OPERATION COST

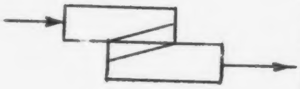
Ion exchangers require between 0 and 0.25 operators per shift.

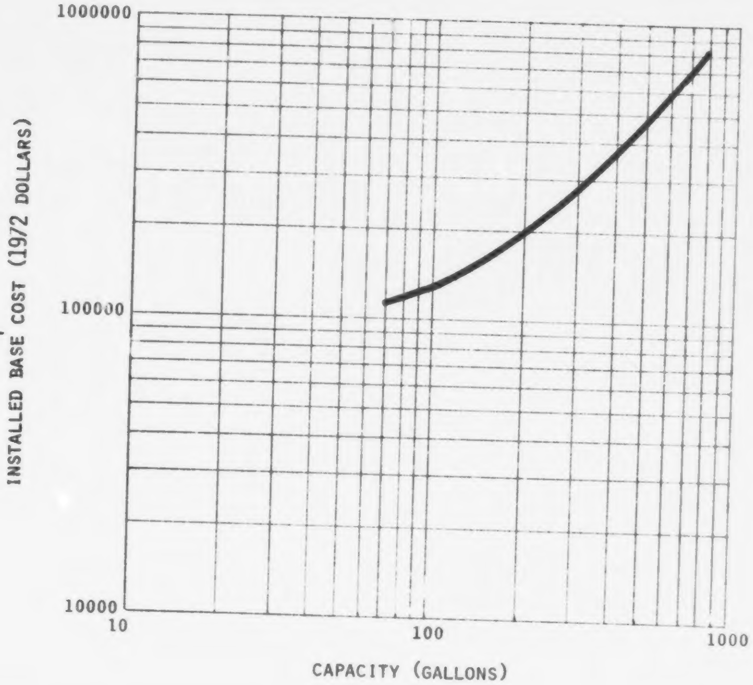
PROBABLE ANNUAL DEPRECIATION RATE

INDUSTRY GROUP	DEPRECIATION RATE (percent)	EXPECTED LIFETIME (years)
Heavy Chemical	0.071-0.091	11-14
Oil and Gas Refining	0.063-0.071	14-16
Resins and Polymers	0.071-0.111	9-14
Food and Beverage	0.056-0.091	11-18
Pulp and Paper	0.063-0-100	10-16
Mining	0.063-0.100	10-18

KNEADER

KNEADER





DESIGN ADJUSTMENT

Type	F_D
Stationary	1.000
Tilting	1.328
Vacuum Tilting	1.764

REGIONAL ADJUSTMENT

Region	F_R
1	1.000
2	1.034
3	0.942
4	1.033
5	1.113
6	1.035
7	1.048
8	1.058
9	1.059
10	1.019

MATERIAL ADJUSTMENT

Material	F_M
CS	0.000
SS304	0.402
SS316	0.625
Monel	0.802

Installed kneader cost includes purchased cost of kneader, motor and drive, accessories, handling and setting, piping, concrete, instrumentation, electrical, paint, and indirect costs (prime contractor engineering and construction overhead).

INSTALLED KNEADER COST,\$ = (INSTALLED BASE COST)$(F_D + F_M)(F_R)$

ANNUAL MAINTENANCE

Annual maintenance will be approximately 3 percent of installed kneader cost.

OPERATION COST

Kneaders require approximately 0.5 operators per shift.

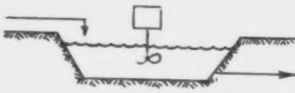
PROBABLE ANNUAL DEPRECIATION RATE

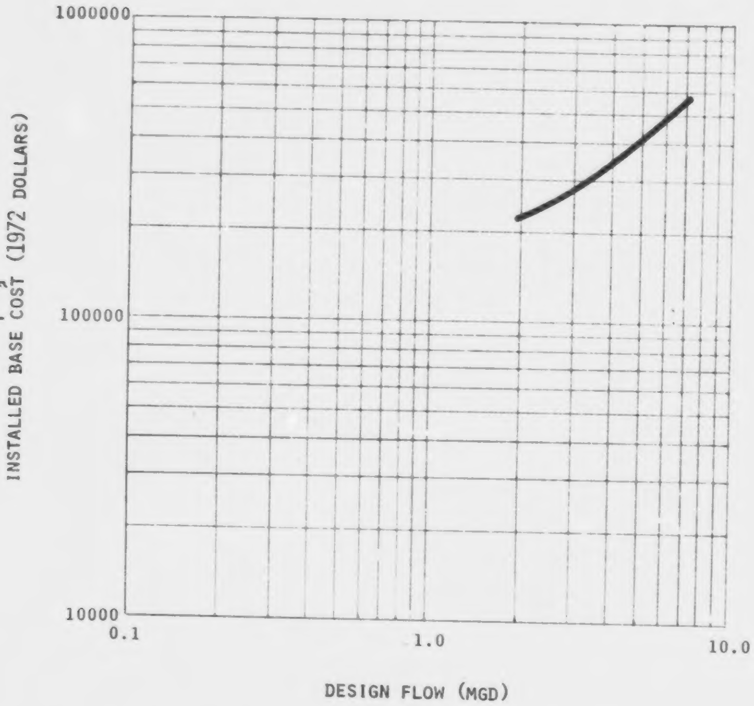
INDUSTRY GROUP	DEPRECIATION RATE (percent)	EXPECTED LIFETIME (years)
Heavy Chemical	0.091	11
Oil and Gas Refining	0.063-0.071	14-16
Resins and Polymers	0.071	14
Food and Beverage	0.056-0.091	11-18
Pulp and Paper	0.063-0.100	10-16
Mining	0.056-0.100	10-18

LS-1

LAGOON SYSTEM

LAGOON SYSTEM





REGIONAL ADJUSTMENT

Region	F_R
1	1.000
2	1.427
3	0.913
4	1.132
5	1.416
6	1.133
7	1.353
8	1.120
9	1.060
10	1.179

Installed lagoon system cost includes excovation, aerators, piping, steel, electrical, paint, and indirect costs (prime contractor engineering and construction overhead).

INSTALLED LAGOON SYSTEM COST,\$ = (INSTALLED BASE COST)(F_R)

ANNUAL MAINTENANCE

Annual maintenance will be approximately 3.89 percent of installed lagoon system.

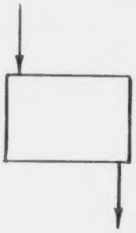
OPERATION COST

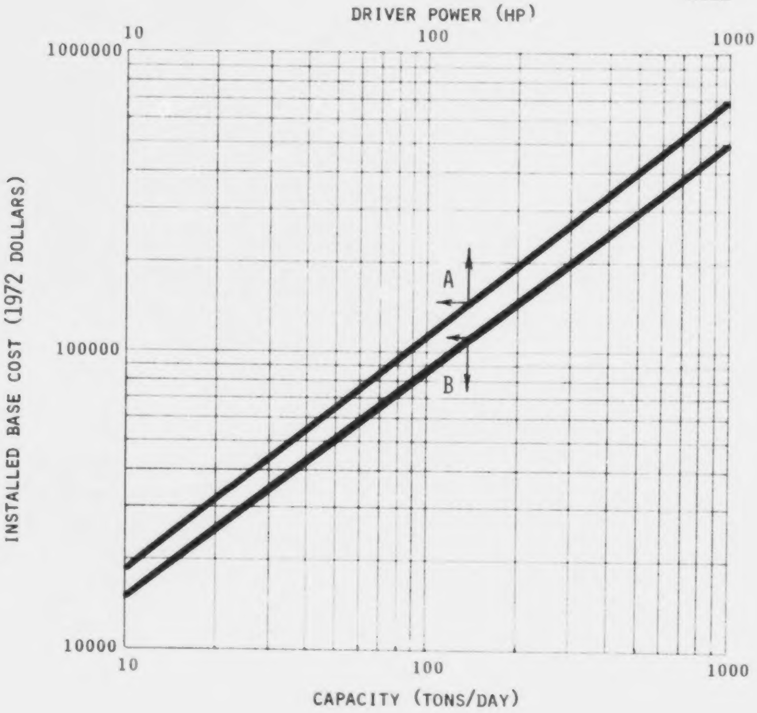
Lagoon systems require no operator attention.

PROBABLE ANNUAL DEPRECIATION RATE

INDUSTRY GROUP	DEPRECIATION RATE (percent)	EXPECTED LIFETIME (years)
Heavy Chemical	0.040	25
Oil and Gas Refining	0.040	25
Resins and Polymers	0.040	25
Food and Beverage	0.040	25
Pulp and Paper	0.040	25
Mining	0.040	25

MILL





DESIGN ADJUSTMENT

Type	Curve	F_D
Ball	A	1.000
Ball	B	1.000
Attrition	A	0.229
Swing Hammer	A	0.388
Mikro Pulverizer	A	1.331
Roller	A	1.174
Hammer	B	0.707

REGIONAL ADJUSTMENT

Region	F_R
1	1.000
2	1.021
3	0.935
4	1.028
5	1.126
6	1.035
7	1.046
8	1.056
9	1.053
10	1.014

Installed mill cost includes purchased cost of mill, accessories, motor and drive, handling and setting, piping, concrete, instrumentation, electrical, paint, and indirect costs (prime contractor engineering and construction overhead).

INSTALLED MILL COST,\$ = (INSTALLED BASE COST)(F_R)

ANNUAL MAINTENANCE

Annual maintenance will vary from 6.1 - 6.5 percent of installed mill cost and will depend upon material abrasiveness and process thruput.

OPERATION COST

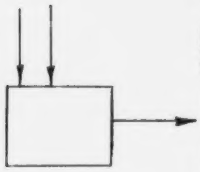
Mills require between 0.25 and 0.50 operators per shift.

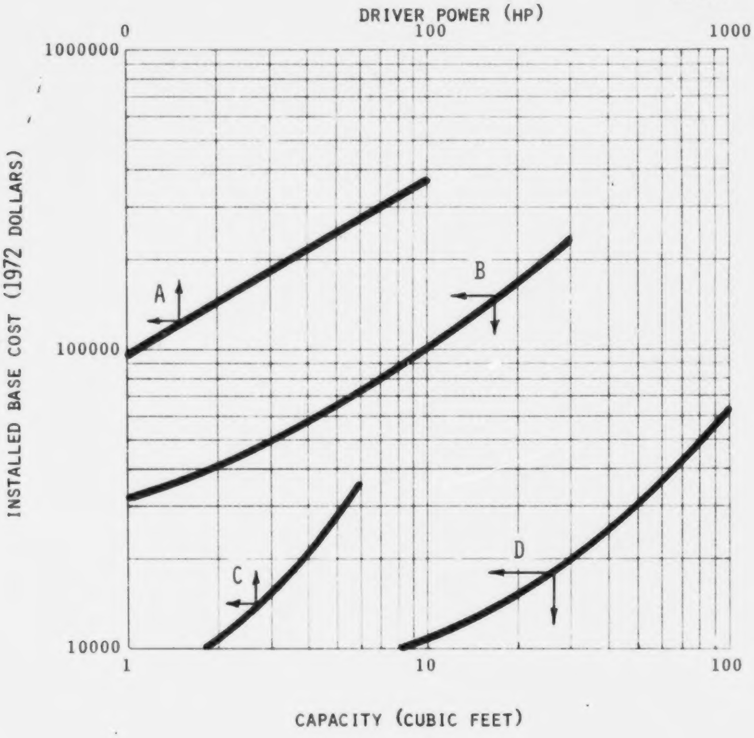
PROBABLE ANNUAL DEPRECIATION RATE

INDUSTRY GROUP	DEPRECIATION RATE (Percent)	EXPECTED LIFETIME (years)
Heavy Chemical	0.05-0.091	11-20
Oil and Gas Refining	0.063-0.071	14-16
Resins and Polymers	0.071-0.111	9-14
Food and Beverage	0.056-0.091	11-18
Pulp and Paper	0.063-0.100	10-16
Mining	0.063-0.100	10-18

MIXER

MIXER





DESIGN ADJUSTMENT

Type	Curve	F_D
Sigma	B	1.000
Fixed Propeller	C	1.000
Extruder	A	1.000
Muller Extruder	A	0.694
Spiral **Ribbon**	D	1.000
Two-Roll	A	0.660
Portable Propeller	C	0.185
Pan	D	2.372

REGIONAL ADJUSTMENT

Region	F_R
1	1.000
2	1.037
3	0.941
4	1.034
5	1.129
6	1.034
7	1.047
8	1.057
9	1.063
10	1.021

Installed mixer cost includes purchased cost of mixer, motor and drive, accessories, handling and setting, piping, concrete, instrumentation, electrical, paint, and indirect costs (prime contractor engineering and construction overhead).

$$\text{INSTALLED MIXER COST.\$} = (\text{INSTALLED BASE COST})\,(F_D)(F_R)$$

ANNUAL MAINTENANCE

Annual maintenance will vary from 1.33 - 1.36 percent of installed mixer cost.

OPERATION COST

Mixers require between 0.1 and 0.5 operators per shift.

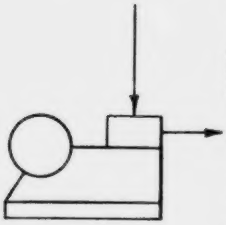
PROBABLE ANNUAL DEPRECIATION RATE

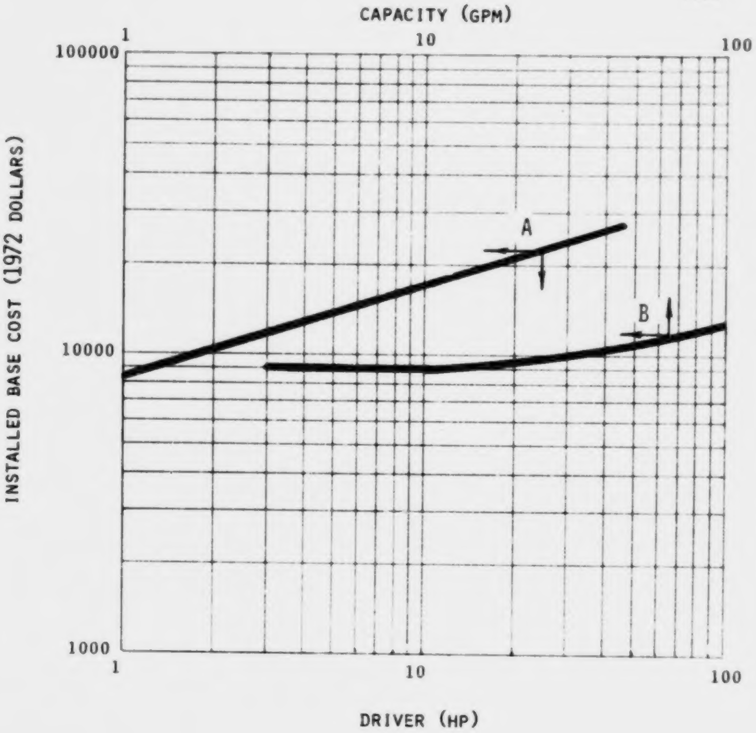
INDUSTRY GROUP	DEPRECIATION RATE (percent)	EXPECTED LIFETIME (years)
Heavy Chemical	0.05-0.091	11-20
Oil and Gas Refining	0.063-0.071	14-16
Resins and Polymers	0.071-0.111	9-14
Food and Beverage	0.056-0.091	11-18
Pulp and Paper	0.063-0.100	10-16
Mining	0.063-0.100	10-18

P-1

PUMP

PUMP





DESIGN ADJUSTMENT

Type	Curve	F_D
Simplex	A	1.000
Duplex	A	1.298
Triplex	A	1.960
Diaphragm	B	1.000
Slurry	B	1.104
Rotary	B	0.466
Gear	B	0.590

REGIONAL ADJUSTMENT

Region	F_R
1	1.000
2	1.064
3	0.978
4	1.034
5	1.076
6	1.027
7	1.066
8	1.029
9	1.067
10	1.033

Installed pump cost includes purchased cost of pump, motor and drive, base plate, coupling, handling and setting, piping, concrete, instrumentation, electrical, insulation, paint, and indirect costs (prime contractor engineering and construction overhead).

INSTALLED PUMP COST.$ = (INSTALLED BASE COST)$(F_D)(F_R)$

ANNUAL MAINTENANCE

Annual maintenance will vary from 0.558 - 2.11 percent of installed pump cost and will depend upon fluid velocity, temperature, pressure and fluid corrosive characteristics.

OPERATION COST

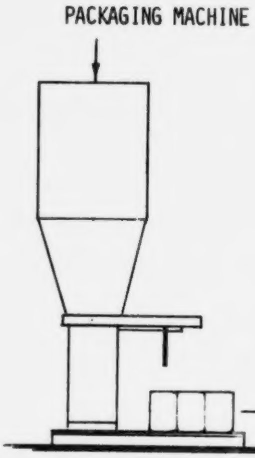
Pumps require no operator attention.

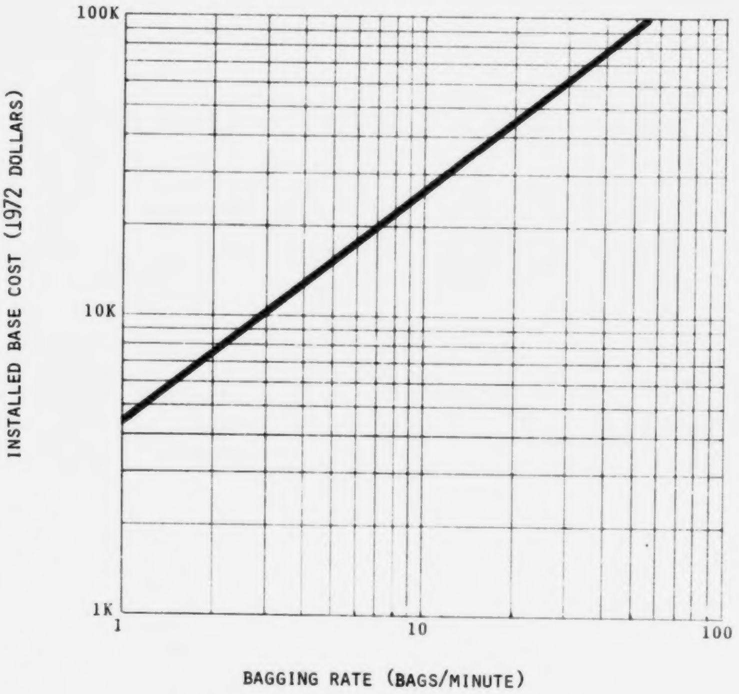
PROBABLE ANNUAL DEPRECIATION RATE

INDUSTRY GROUP	DEPRECIATION RATE (percent)	EXPECTED LIFETIME (years)
Heavy Chemical	0.05-0.091	11-20
Oil and Gas Refining	0.063-0.071	14-16
Resins and Polymers	0.071-0.111	9-14
Food and Beverage	0.056-0.091	11-18
Pulp and Paper	0.063-0.100	10-16
Mining	0.063-0.100	10-18

PKG-1

PACKAGING MACHINE





DESIGN ADJUSTMENT

Type	F_D
Bagging Machine -Bagged by volume	1.00
Bagging Machine -Bagged by weight	3.23

REGIONAL ADJUSTMENT

Region	F_R
1	1.000
2	1.026
3	0.938
4	1.029
5	1.135
6	1.035
7	1.048
8	1.058
9	1.058
10	1.016

Installed packaging machine cost includes purchased cost of packaging machine, accessories, motor and drive, handling and setting, piping and ductwork, concrete, steel, instrumentation, electrical, insulation, paint, and indirect costs (prime contractor engineering and construction overhead).

INSTALLED PACKAGING MACHINE COST,\$ = (INSTALLED BASE COST)$(F_D)(F_R)$

ANNUAL MAINTENANCE

Annual maintenance will vary from 2.4 - 2.6 percent of installed packaging machine cost.

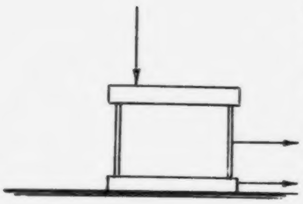
OPERATION COST

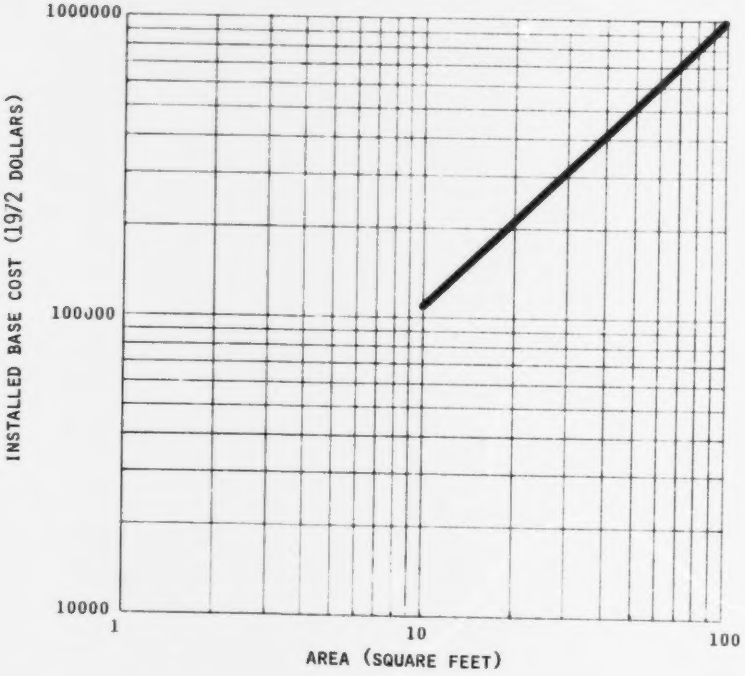
Packaging machines require between 0.5 and 1.0 operators per shift.

PROBABLE ANNUAL DEPRECIATION RATE

INDUSTRY GROUP	DEPRECIATION RATE (percent)	EXPECTED LIFETIME (years)
Heavy Chemical	0.05-0.091	11-20
Oil and Gas Refining	0.063-0.071	14-16
Resins and Polymers	0.071-0.111	9-14
Food and Beverage	0.056-0.091	11-18
Pulp and Paper	0.063-0.100	10-16
Mining	0.063-0.100	10-18

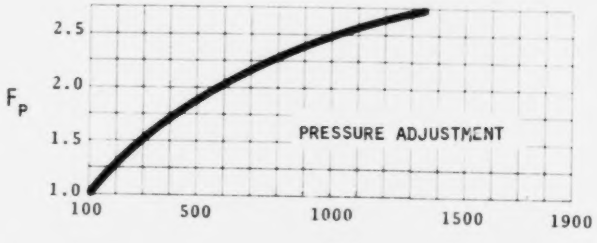
PRESS





REGIONAL ADJUSTMENT

Region	F_R
1	1.000
2	0.988
3	0.896
4	1.027
5	1.185
6	1.045
7	1.048
8	1.088
9	1.039
10	1.005



Installed press cost includes purchased cost of press, setting and handling, piping, concrete, instrumentation, electrical, paint, and indirect costs (prime contractor engineering and construction overhead).

INSTALLED PRESS COST,\$ = (INSTALLED BASE COST) $(F_P)(F_R)$

ANNUAL MAINTENANCE

Annual maintenance will be approximately 2.5 percent of installed press.

OPERATION COST

Presses require between 0.125 and 0.25 operators per shift.

PROBABLE ANNUAL DEPRECIATION RATE

INDUSTRY GROUP	DEPRECIATION RATE (percent)	EXPECTED LIFETIME (years)
Heavy Chemical	0.05-0.091	11-20
Oil and Gas Refining	0.063-0.071	14-16
Resins and Polymers	0.071-0.111	9-14
Food and Beverage	0.056-0.091	11-18
Pulp and Paper	0.063-0.100	10-16
Mining	0.063-0.100	10-18

Installed press cost includes purchased cost of press, setting and handling, piping, concrete, instrumentation, electrical, paint, and indirect costs (prime contractor engineering and construction overhead).

INSTALLED PRESS COST,\$ = (INSTALLED BASE COST) $(F_P)(F_R)$

ANNUAL MAINTENANCE

Annual maintenance will be approximately 2.5 percent of installed press.

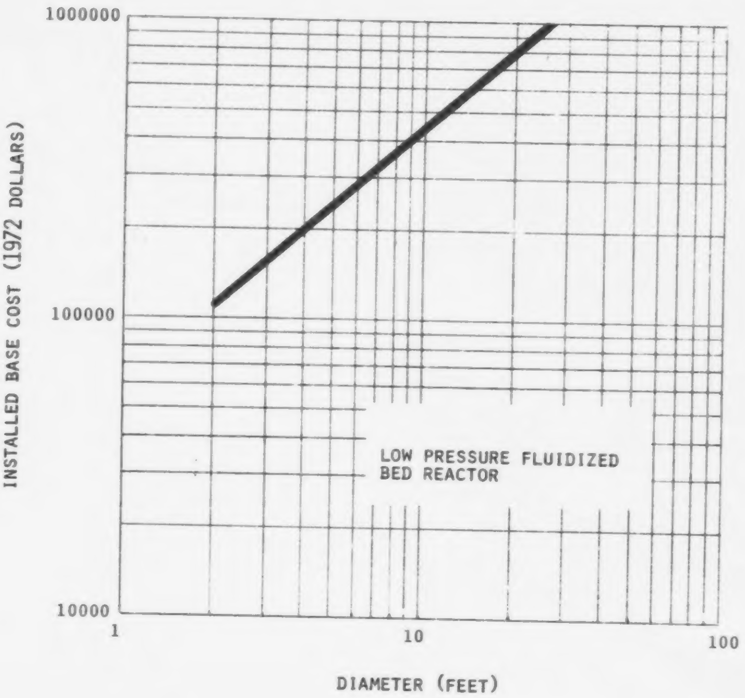
OPERATION COST

Presses require between 0.125 and 0.25 operators per shift.

PROBABLE ANNUAL DEPRECIATION RATE

INDUSTRY GROUP	DEPRECIATION RATE (percent)	EXPECTED LIFETIME (years)
Heavy Chemical	0.05-0.091	11-20
Oil and Gas Refining	0.063-0.071	14-16
Resins and Polymers	0.071-0.111	9-14
Food and Beverage	0.056-0.091	11-18
Pulp and Paper	0.063-0.100	10-16
Mining	0.063-0.100	10-18

REACTOR


1000000
100000
10000
1
10
100
INSTALLED BASE COST (1972 DOLLARS)
DIAMETER (FEET)
LOW PRESSURE FLUIDIZED BED REACTOR

DESIGN ADJUSTMENT

Type	F_D
One Stage	1.000
Two Stage	2.358

REGIONAL ADJUSTMENT

Region	F_R
1	1.000
2	1.061
3	0.984
4	1.032
5	1.073
6	1.024
7	1.062
8	1.024
9	1.065
10	1.031

Installed reactor cost includes purchased cost of reactor, auxiliaries, handling and setting, piping, concrete, steel, instrumentation, electrical, insulation, paint, and indirect costs (prime contractor engineering and construction overhead).

INSTALLED REACTOR COST,\$ = (INSTALLED BASE COST)$(F_D)(F_R)$

ANNUAL MAINTENANCE

Annual maintenance will be approximately 2.47 percent of installed reactor cost.

OPERATION COST

Reactors require approximately 0.25 operators per shift.

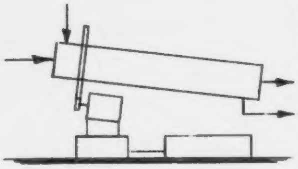
PROBABLE ANNUAL DEPRECIATION RATE

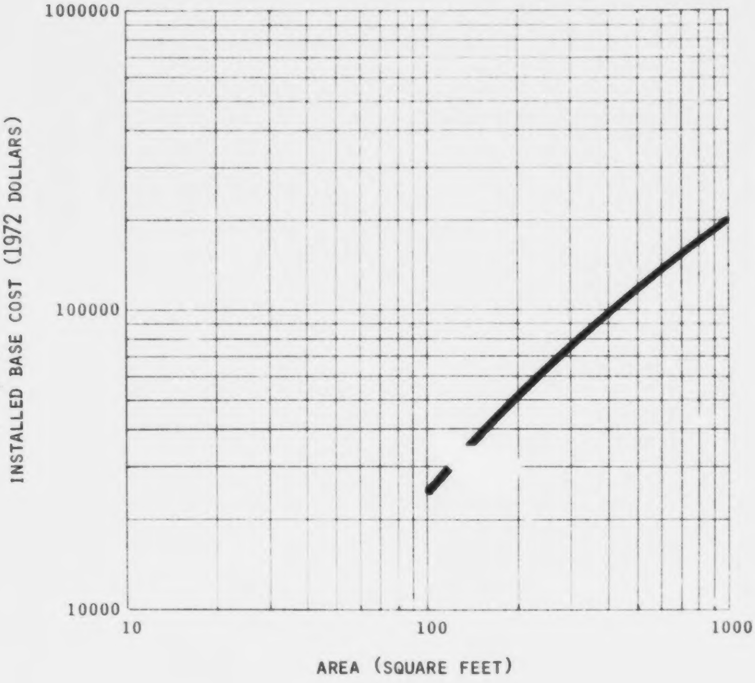
INDUSTRY GROUP	DEPRECIATION RATE (percent)	EXPECTED LIFETIME (years)
Heavy Chemical	.050-0.091	11-20
Oil and Gas Refining	0.063-0.071	14-16
Resins and Polymers	0.071	14
Food and Beverage	0.056-0.091	11-18
Pulp and Paper	0.063-0.100	10-16
Mining	0.056-0.100	10-18

RD-1

ROTARY DRYER

ROTARY DRYER





DESIGN ADJUSTMENT

Type	F_D
Direct Gas Heating	1.000
Indirect Gas Heating	1.380
Vacuum	4.192
Jacketed Vacuum	5.870

REGIONAL ADJUSTMENT

Region	F_R
1	1.000
2	1.059
3	0.957
4	1.045
5	1.123
6	1.040
7	1.074
8	1.058
9	1.074
10	1.035

Installed rotary dryer cost includes purchased cost of rotary dryer, motor and drive, accessories, handling and setting, piping, concrete, steel, instrumentation, electrical, paint, and indirect costs (prime contractor engineering and construction overhead).

INSTALLED ROTARY DRYER COST.\$ = (INSTALLED BASE COST) $(F_D)(F_R)$

ANNUAL MAINTENANCE

Annual maintenance will vary from 2.13 - 2.24 percent of installed dryer cost.

OPERATION COST

Rotary dryers require between 0.2 and 0.5 operators per shift.

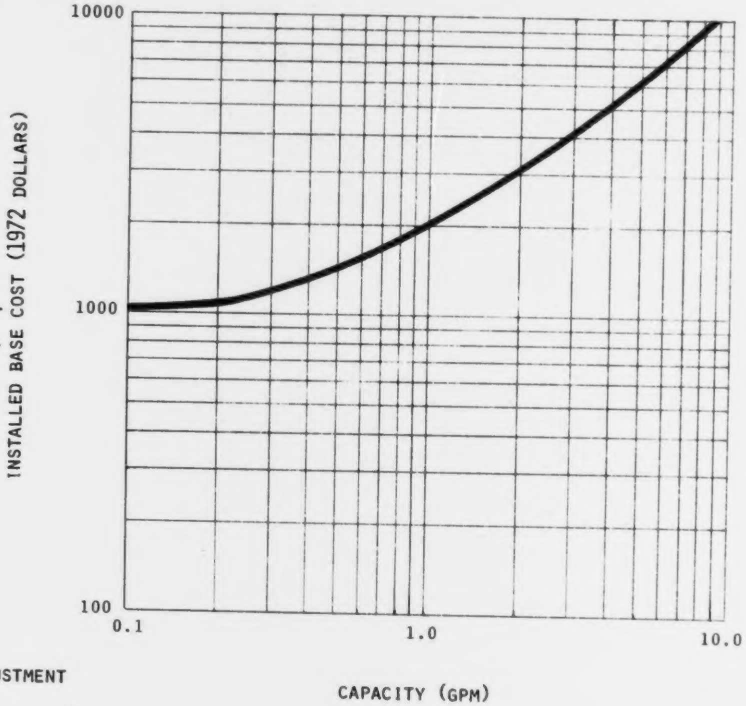
PROBABLE ANNUAL DEPRECIATION RATE

INDUSTRY GROUP	DEPRECIATION RATE (percent)	EXPECTED LIFETIME (years)
Heavy Chemical	0.05-0.091	11-20
Oil and Gas Refining	0.063-0.071	14-16
Resins and Polymers	0.071-0.111	9-14
Food and Beverage	0.056-0.091	11-18
Pulp and Paper	0.063-0.100	10-16
Mining	0.063-0.100	10-18

ROS-1

REVERSE OSMOSIS SYSTEM

REVERSE OSMOSIS SYSTEM



DESIGN ADJUSTMENT

Type	F_D
Hollow Fine Fiber	1.000
Spiral Wound	1.390
Tubular	1.615

REGIONAL ADJUSTMENT

Region	F_R
1	1.000
2	1.073
3	0.978
4	1.036
5	1.083
6	1.029
7	1.071
8	1.027
9	1.074
10	1.035

Installed reverse osmosis module cost includes purchased cost of reverse osmosis module, membrane, membrane installation, handling and setting, piping, concrete, instrumentation, paint, and indirect costs (prime contractor engineering and construction overhead).

INSTALLED REVERSE OSMOSIS **SYSTEM** COST, $ = (INSTALLED BASE COST)$(F_D)(F_R)$

ANNUAL MAINTENANCE

Annual maintenance will vary considerably depending upon application and membrane life. Average annual maintenance can be estimated to be approximately 10 percent of installed reverse osmosis module cost.

OPERATION COST

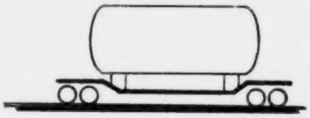
Reverse osmosis **system** require no operator attention.

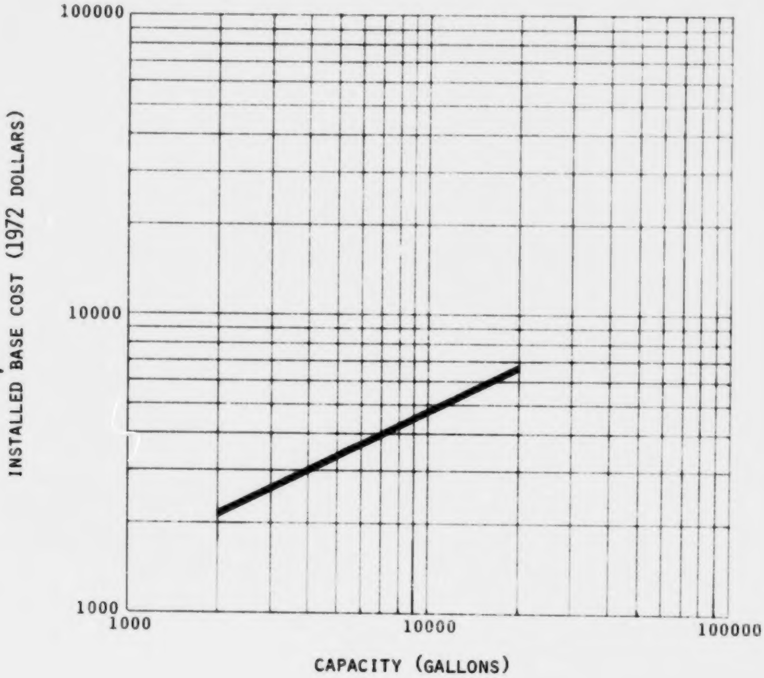
PROBABLE ANNUAL DEPRECIATION RATE

INDUSTRY GROUP	DEPRECIATION RATE (percent)	EXPECTED LIFETIME (years)
Heavy Chemical	0.050-0.091	11-20
Oil and Gas Refining	0.045	22
Resins and Polymers	0.045	22
Food and Beverage	0.045	22
Pulp and Paper	0.045	22
Mining	0.045	22

RAILROAD TANK CAR

RAILROAD TANK CAR





Installed railroad tank car cost includes purchased cost of railroad rank car and delivery.

INSTALLED RAILROAD TANK CAR COST,$ = INSTALLED BASE COST

ANNUAL MAINTENANCE

Annual maintenance will be approximately 4.9 percent of installed railroad tank car cost.

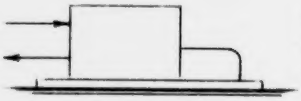
OPERATION COST

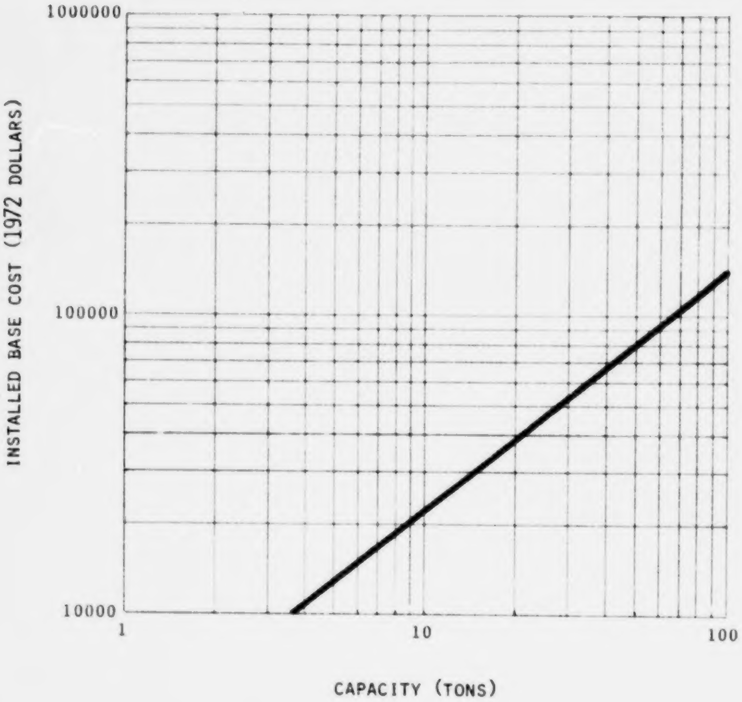
Railroad tank cars require no operator attention.

PROBABLE ANNUAL DEPRECIATION RATE

INDUSTRY GROUP	DEPRECIATION RATE (percent)	EXPECTED LIFETIME (years)
Heavy Chemical	0.050-0.091	11-20
Oil and Gas Refining	0.045	22
Resins and Polymers	0.045	22
Food and Beverage	0.045	22
Pulp and Paper	0.045	22
Mining	0.045	22

REFRIGERATION UNIT



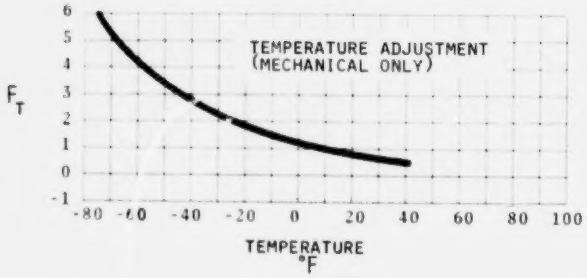


DESIGN ADJUSTMENT

Type	Temperature	F_D
Mechanical	0°F	1.000
Steam Jet	60°F	0.836

REGIONAL ADJUSTMENT

Region	F_R
1	1.000
2	1.067
3	0.973
4	1.036
5	1.091
6	1.030
7	1.061
8	1.035
9	1.067
10	1.031



Installed refrigeration unit cost includes purchased cost of refrigeration unit, auxiliaries, field erection and indirect costs (prime contractor engineering and construction overhead).

INSTALLED REFRIGERATION UNIT COST,$ = (INSTALLED BASE COST) $(F_D)(F_T)(F_R)$

ANNUAL MAINTENANCE

Annual maintenance will be approximately 5 percent of installed refrigeration unit cost.

OPERATION COST

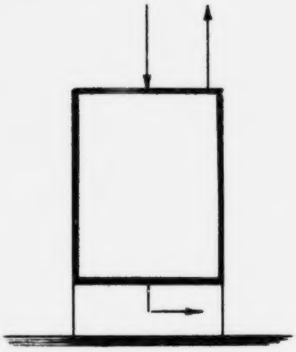
Refrigeration units require no operator attention.

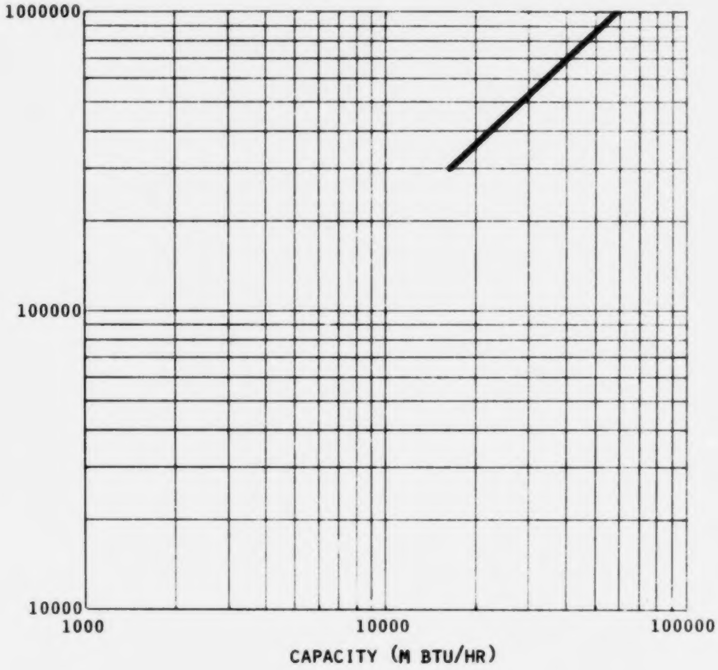
PROBABLE ANNUAL DEPRECIATION RATE

INDUSTRY GROUP	DEPRECIATION RATE (percent)	EXPECTED LIFETIME (years)
Heavy Chemical	0.071-0.091	11-14
Oil and Gas Refining	0.063-0.0	14-16
Resins and Polymers	0.071-0.111	9-14
Food and Beverage	0.056-0.091	11-18
Pulp and Paper	0.063-0.100	10-16
Mining	0.063-0.100	10-18

SUBMERGED COMBUSTION SYSTEM

SUBMERGED COMBUSTION SYSTEM





REGIONAL ADJUSTMENT

Region	F_R
1	1.000
2	1.074
3	0.979
4	1.036
5	1.079
6	1.027
7	1.071
8	1.026
9	1.069
10	1.036

Installed submerged combustion system cost includes purchased cost of evaporator, blower, drives, heating unit, handling and setting, piping, concrete, steel, instrumentation, electrical, insulation, paint, and indirect costs (prime contractor engineering and construction overhead).

INSTALLED SUBMERGED COMBUSTION SYSTEM COST,\$ = (INSTALLED BASE COST)(F_R)

ANNUAL MAINTENANCE

Annual maintenance will vary from 0.2 to 6 percent of installed submerged combustion system cost.

OPERATION COST

Submerged combustion systems require between 0.125 and 1.0 operators per shift.

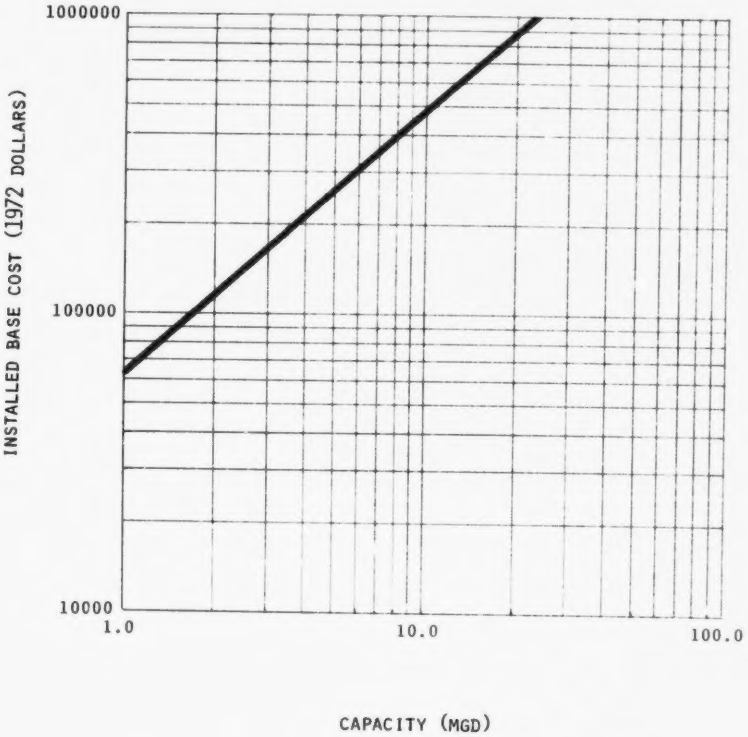
PROBABLE ANNUAL DEPRECIATION RATE

INDUSTRY GROUP	DEPRECIATION RATE (percent)	EXPECTED LIFETIME (years)
Heavy Chemical	0.091	11
Oil and Gas Refining	0.063-0.071	14-16
Resins and Polymers	0.071	14
Food and Beverage	0.056-0.083	12-18
Pulp and Paper	0.063-0.100	10-16
Mining	0.063-0.100	10-18

SS-1

SEDIMENTATION SYSTEM

SEDIMENTATION SYSTEM



REGIONAL ADJUSTMENT

Region	F_R
1	1.000
2	1.045
3	0.947
4	1.043
5	1.133
6	1.041
7	1.066
8	1.065
9	1.067
10	1.029

Installed sedimentation system cost includes purchased cost of tanks, pumps, notors and drives, piping, concrete, structural steel, instrumentation, electrical, paint, and indirect costs (prime contractor engineering and construction overhead).

INSTALLED SEDIMENTATION SYSTEM COST, \$ = (INSTALLED BASE COST) (F_R)

ANNUAL MAINTENANCE

Annual maintenance will be approximately 5-16 percent of installed sedimentation system cost.

OPERATION COST

Sedimentation systems require no operator attention.

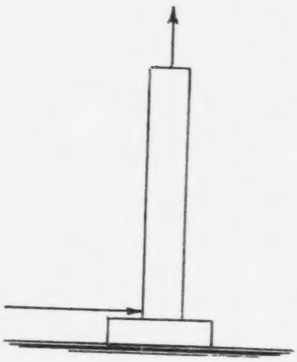
PROBABLE DEPRECIATION RATE

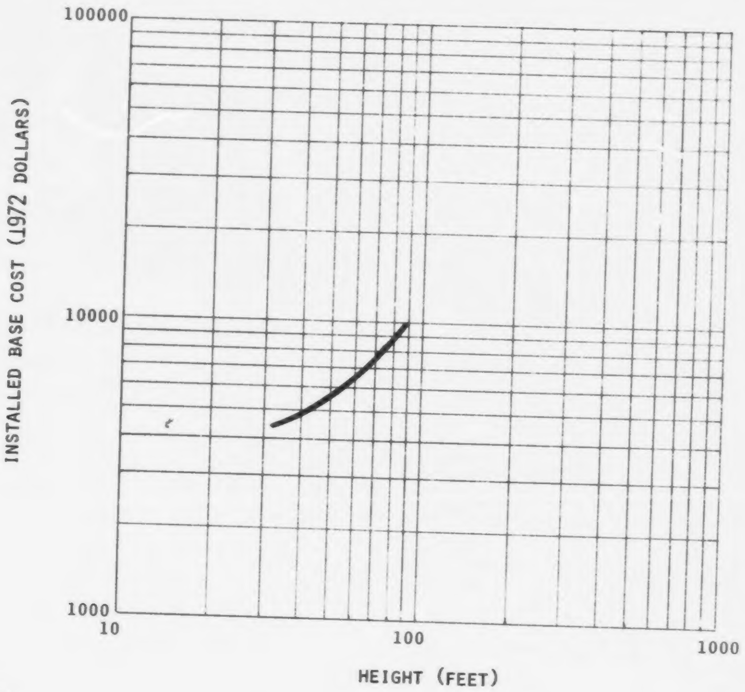
INDUSTRY GROUP	DEPRECIATION RATE (percent)	EXPECTED LIFETIME (years)
Heavy Chemical	0.016-0.040	25-60
Oil and Gas Refining	0.016-0.040	25-60
Resins and Polymers	0.016-0.040	25-60
Food and Beverage	0.016-0.040	25-60
Pulp and Paper	0.016-0.040	25-60
Mining	0.016-0.040	25-60

STK-1

STACK

STACK





DESIGN ADJUSTMENT

Diameter (inches)	F_D
24	1.000
36	2.220
48	2.970

REGIONAL ADJUSTMENT

Region	F_D
1	1.000
2	1.061
3	0.984
4	1.032
5	1.073
6	1.024
7	1.062
8	1.024
9	1.065
10	1.031

Installed stack cost includes purchased cost of stack, handling and setting, piping and duckwork, concrete, steel, insulation, paint, and indirect costs (prime contractor engineering and construction overhead).

INSTALLED STACK COST.$ = (INSTALLED BASE COST) $(F_D)(F_R)$

ANNUAL MAINTENANCE

Annual maintenance will vary from 0.2 to 1 percent of installed stack cost.

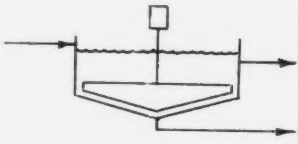
OPERATION COST

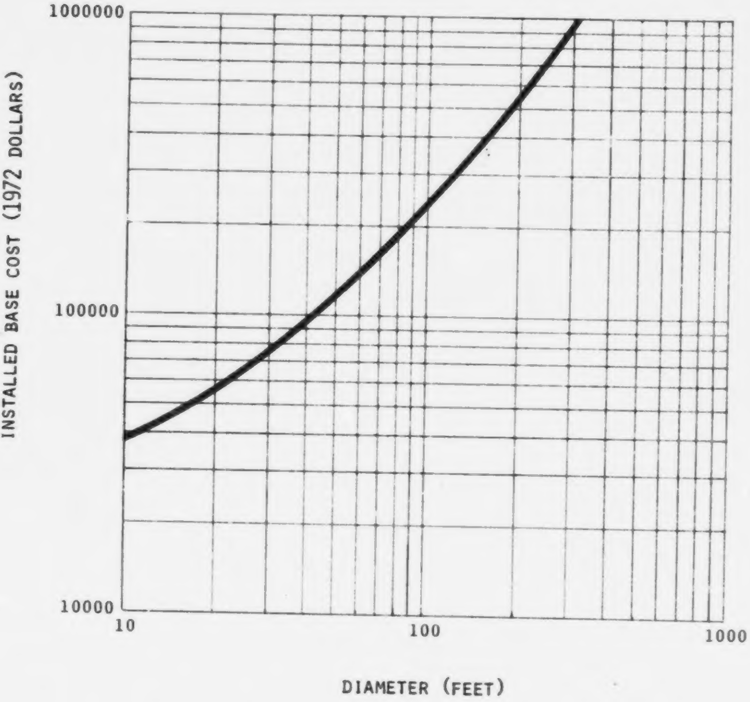
Stacks require no operator attention.

PROBABLE ANNUAL DEPRECIATION RATE

INDUSTRY GROUP	DEPRECIATION RATE (percent)	EXPECTED LIFETIME (years)
Heavy Chemical	0.050-0.091	11-20
Oil and Gas Refining	0.045	22
Resins and Polymers	0.045	22
Food and Beverage	0.045	22
Pulp and Paper	0.045	22
Mining	0.045	22

THICKENER





REGIONAL ADJUSTMENT

Region	F_R
1	1.000
2	1.061
3	0.984
4	1.032
5	1.073
6	1.024
7	1.062
8	1.024
9	1.065
10	1.031

Installed thickener cost includes purchased cost of thickener, erection, site preparation, pumps, piping, concrete, steel, instrumentation, electrical, paint, and indirect costs (prime contractor engineering and construction overhead).

INSTALLED THICKENER COST,$ = (INSTALLED BASE COST)(F_R)

ANNUAL MAINTENANCE

Annual maintenance will be approximately 1 percent of installed thickener cost.

OPERATION COST

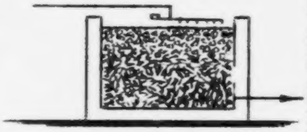
Thickeners require no operator attention.

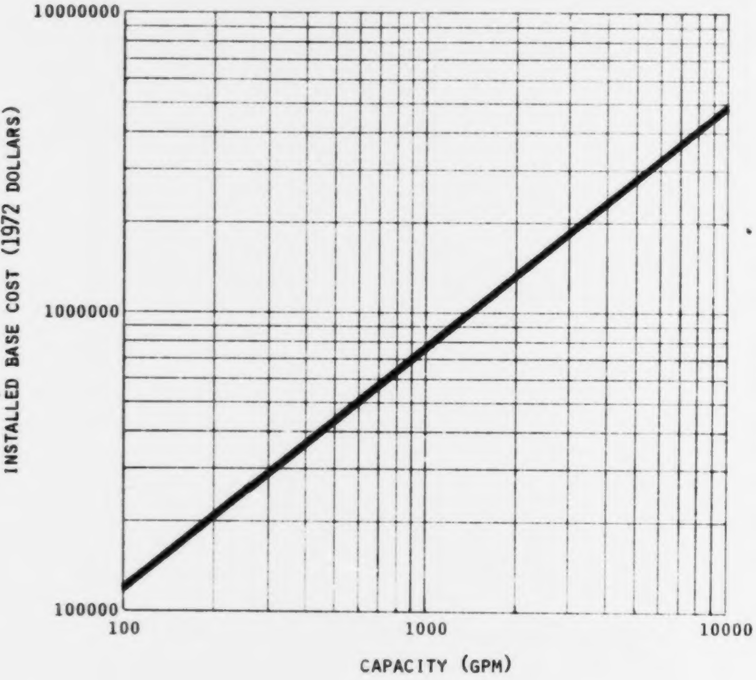
PROBABLE ANNUAL DEPRECIATION RATE

INDUSTRY GROUP	DEPRECIATION RATE (percent)	EXPECTED LIFETIME (years)
Heavy Chemical	0.016-0.040	25-60
Oil and Gas Refining	0.016-0.040	25-60
Resins and Polymers	0.016-0.040	25-60
Food and Beverage	0.016-0.040	25-60
Pulp and Paper	0.016-0.040	25-60
Mining	0.016-0.040	25-60

TRICKLING FILTER

TRICKLING FILTER





REGIONAL ADJUSTMENT

Region	F_R
1	1.000
2	1.045
3	0.947
4	1.043
5	1.133
6	1.041
7	1.066
8	1.065
9	1.067
10	1.029

Installed trickling filter cost includes purchased cost of mechanism, notor and drive, rock packing, setting packing, concrete, steel, instrumentation, electrical, insulation, paint and indirect costs (prime contractor engineering and construction overhead).

INSTALLED TRICKLING FILTER COST,\$ - (INSTALLED BASE COST) (F_R)

ANNUAL MAINTENANCE

Annual maintenance will be approximately 3.3 percent of the installed trickling filter cost.

OPERATION COST

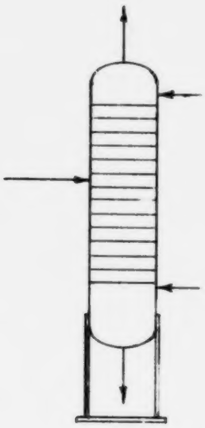
Trickling filters require no operator attention.

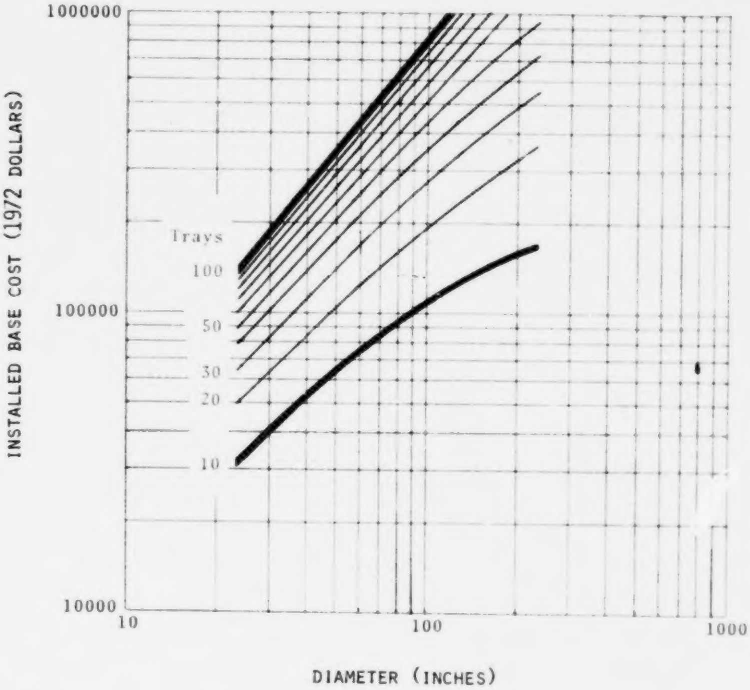
PROBABLE ANNUAL DEPRECIATION RATE

INDUSTRY GROUP	DEPRECIATION RATE (percent)	EXPECTED LIFETIME (years)
Heavy Chemical	0.025-0.050	20-40
Oil and Gas Refining	0.025-0.050	20-40
Resins and Polymers	0.025-0.050	20-40
Food and Beverage	0.025-0.050	20-40
Pulp and Paper	0.025-0.050	20-40
Municipal Usage	0.025-0.050	20-40

TRAY TOWER

TOWER





DESIGN ADJUSTMENT

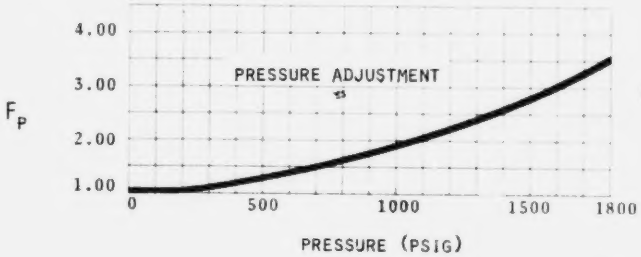
Type	F_D
Bubble Cap	1.000
Koch Kascade	1.243
Plate Tray	0.852
Sieve Tray	0.874
Turbo Grid	0.855
Valve Tray	0.911

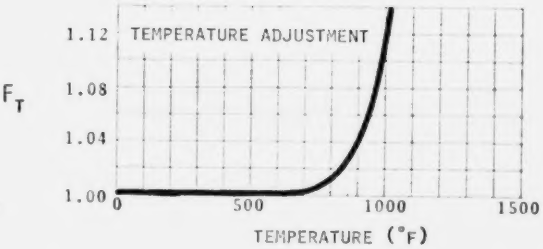
MATERIAL ADJUSTMENT

Material	F_M
CS	1.000
SS304	1.300
SS316	1.503
SS347	1.578
Ni	3.579
Cu	6.056
Brass	5.102
A 515 CS	0.991
Monel	2.419
Moly	4.193
Ti	5.052

REGIONAL ADJUSTMENT

Region	F_R
1	1.000
2	1.062
3	0.977
4	1.035
5	1.080
6	1.026
7	1.064
8	1.028
9	1.071
10	1.028





Installed tray tower cost includes purchased cost of tray tower, trays, handling and setting, piping, concrete, steel, instrumentation, electrical, paint, and indirect costs (prime contractor engineering and construction overhead).

INSTALLED TRAY TOWER COST.\$ = (INSTALLED BASE COST)$(F_P)(F_D)(F_M)(F_R)(F_T)$

ANNUAL MAINTENANCE

Annual maintenance will vary from 7.35 - 10.71 percent of installed tray tower cost and will depend upon temperature, pressure, fluid corrosivity and fluid velocity.

OPERATION COST

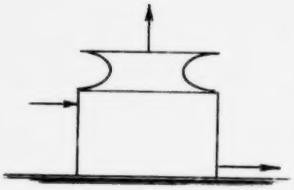
Tray towers require approximately 0.25 operators per shift.

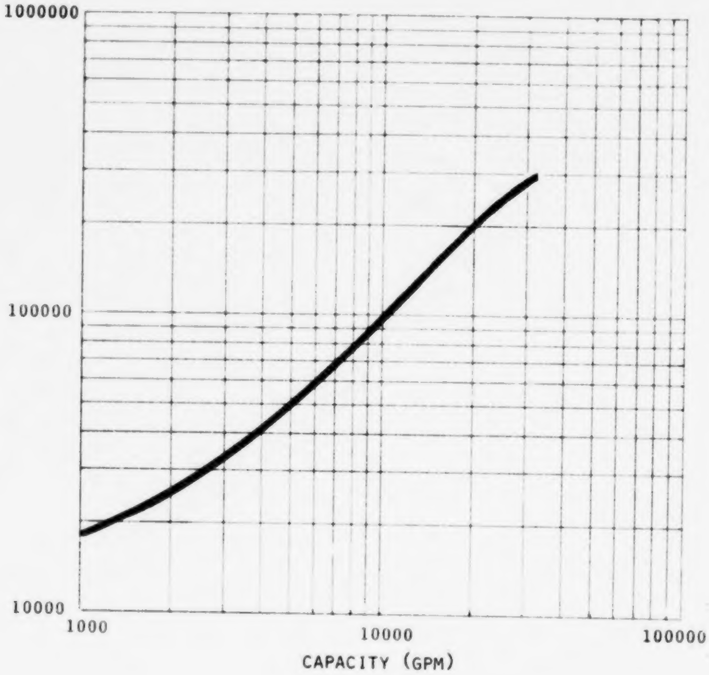
PROBABLE ANNUAL DEPRECIATION RATE

INDUSTRY GROUP	DEPRECIATION RATE (percent)	EXPECTED LIFETIME (years)
Heavy Chemical	0.071-0.091	11-14
Oil and Gas Refining	0.063-0.071	14-16
Resins and Polymers	0.071	14
Food and Beverage	0.056- .083	12-18
Pulp and Paper	0.063	16
Mining	0.063-0.100	10-18

COOLING TOWERS

COOLING TOWERS





REGIONAL ADJUSTMENT

Region	F_R
1	1.000
2	1.061
3	0.984
4	1.032
5	1.073
6	1.024
7	1.062
8	1.024
9	1.065
10	1.031

Installed cooling tower cost includes purchased cost of cooling tower, basin, handling and setting, piping, concrete foundations and footings, instrumentation, paint, and indirect costs (prime contractor engineering and construction overhead).

INSTALLED COOLING TOWER COST, $ = (INSTALLED BASE COST) (F_R)

ANNUAL MAINTENANCE

Annual maintenance will be approximately 3 percent of installed cooling tower cost.

OPERATION COST

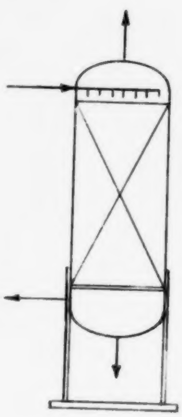
Cooling towers require no operator attention.

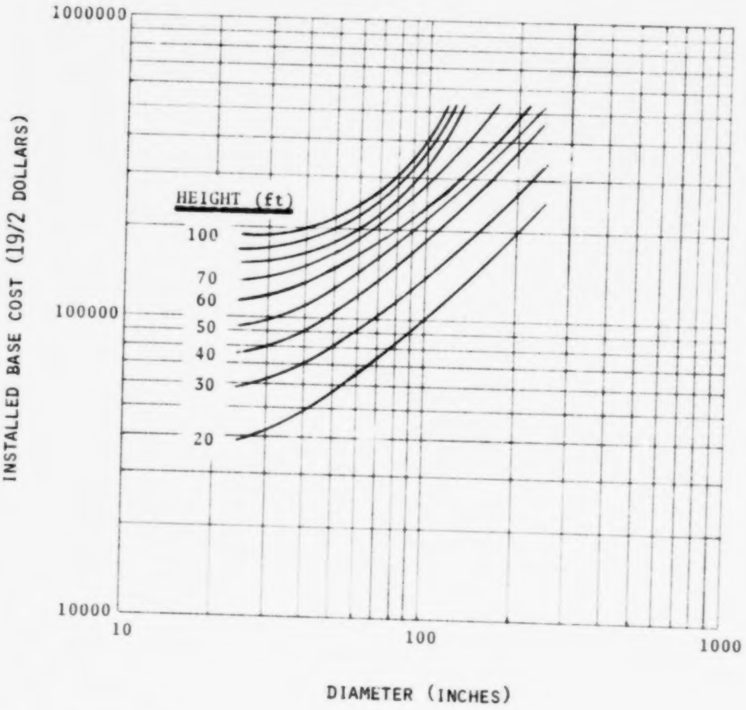
PROBABLE ANNUAL DEPRECIATION RATE

INDUSTRY GROUP	DEPRECIATION RATE (percent)	EXPECTED LIFETIME (years)
Heavy Chemical	0.071-0.091	11-14
Oil and Gas Refining	0.063-0.071	14-16
Resins and Polymers	0.071	14
Food and Beverage	0.056- .083	12-18
Pulp and Paper	0.063	16
Mining	0.063-0.100	10-18

PACKED COLUMN

PACKED COLUMN



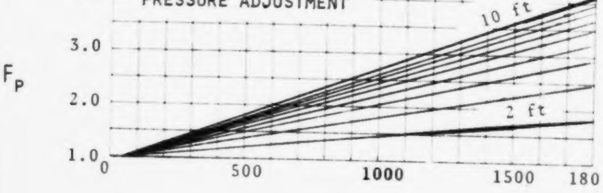


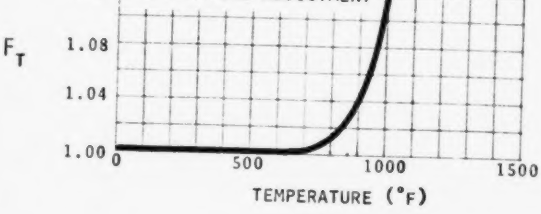
MATERIAL ADJUSTMENT

Material	F_M
CS	1.000
SS304	1.042
SS347	1.060
Ni	1.801
Ti	2.420
Cu	3.365
Al	3.339
A 515 CS	1.007
A 204 CS	1.064

REGIONAL ADJUSTMENT

Region	F_R
1	1.000
2	1.076
3	1.073
4	1.043
5	1.097
6	1.034
7	1.042
8	1.036
9	1.079
10	1.037





PACKING TYPE	F_K
Activated carbon	16.40
Alumina	15.10
Calcium chloride	4.11
Coke	2.05
Crushed limestone	4.11
Resin	93.10
Silica gel	34.20
0.5 inch diameter berl saddles, stoneware	32.80
.75 inch diameter berl saddles, stoneware	21.90
1.0 inch diameter berl saddles, stoneware	13.10
1.5 inch diameter berl saddles, stoneware	9.85
0.5 inch diameter berl saddles, porcelain	39.40
.75 inch diameter berl saddles, porcelain	26.30
1.0 inch diameter berl saddles, porcelain	15.80
1.5 inch diameter berl saddles, porcelain	11.80
0.5 inch diameter berl saddles, steel	65.70
.75 inch diameter berl saddles, steel	43.80
1.0 inch diameter berl saddles, steel	26.30
1.5 inch diameter berl saddles, steel	19.70
0.5 inch diameter berl saddles, stainless steel	82.10
.75 inch diameter berl saddles, stainless steel	54.70
1.0 inch diameter berl saddles, stainless steel	32.80
1.5 inch diameter berl saddles, stainless steel	24.60
0.5 inch diameter berl saddles, karbate	328.00
.75 inch diameter berl saddles, karbate	219.00
1.0 inch diameter berl saddles, karbate	131.00
1.5 inch diameter berl saddles, karbate	98.50
0.5 inch diameter intalox saddles, ceramic	33.40
1.0 inch diameter intalox saddles, ceramic	13.30
1.5 inch diameter intalox saddles, ceramic	10.20
2.0 inch diameter intalox saddles, ceramic	10.40
1.0 inch diameter pall rings, ceramic	71.00
0.5 inch diameter pall rings, polypropylene	58.20
1.0 inch diameter pall rings, polypropylene	36.90
1.5 inch diameter pall rings, polypropylene	29.50
2.0 inch diameter pall rings, polypropylene	26.30
0.5 inch diameter pall rings, stainless steel	26.50
1.0 inch diameter pall rings, stainless steel	13.60
1.5 inch diameter pall rings, stainless steel	11.80
2.0 inch diameter pall rings, stainless steel	9.80
1.0 inch diameter rashig rings, carbon	26.40
1.5 inch diameter rashig rings, carbon	26.10
1.0 inch diameter rashig rings, stoneware	6.30
1.5 inch diameter rashig rings, stoneware	5.06
2.0 inch diameter rashig rings, stoneware	4.38
3.0 inch diameter rashig rings, stoneware	3.70
1.0 inch diameter rashig rings, porcelain	7.56
1.5 inch diameter rashig rings, porcelain	6.08
2.0 inch diameter rashig rings, porcelain	5.26
3.0 inch diameter rashig rings, porcelain	4.43
1.0 inch diameter rashig rings, stainless steel	15.70
1.5 inch diameter rashig rings, stainless steel	12.70
2.0 inch diameter rashig rings, stainless steel	10.90
3.0 inch diameter rashig rings, stainless steel	9.24
1.0 inch diameter rashig rings, karbate	63.00
1.5 inch diameter rashig rings, karbate	50.60
2.0 inch diameter rashig rings, karbate	43.80
3.0 inch diameter rashig rings, karbate	37.00
1.0 inch diameter rashig rings, steel	12.60
1.5 inch diameter rashig rings, steel	10.10
2.0 inch diameter rashig rings, steel	8.76
3.0 inch diameter rashig rings, steel	7.39
Tellerettes H.D. polyethylene 1 inch	26.30
Tellerettes L.D. polyethylene 1 inch	22.70

Installed packed column cost includes purchased cost of packed column less packing and packing installation, handling and setting, piping, concrete, steel, instrumentation, electrical, insulation, paint, and indirect costs (prime contractor engineering and construction overhead).

$$\text{INSTALLED PACKED COLUMN COST, \$} = (\text{INSTALLED BASE COST})\ (F_M)(F_P)(F_R)(F_T) + (F_K)\begin{pmatrix}\text{PACKING}\\ \text{VOLUME}\\ \text{IN}\\ \text{CUBIC}\\ \text{FEET}\end{pmatrix}$$

ANNUAL MAINTENANCE

Annual maintenance will vary from 3.60 - 3.97 percent of installed packed column cost and will depend upon fluid corrosivity, temperature, pressure, and fluid velocity.

OPERATION COST

Packed columns require approximately 0.25 operators per shift.

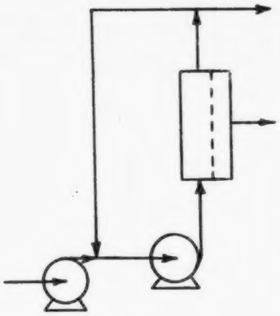
PROBABLE ANNUAL DEPRECIATION RATE

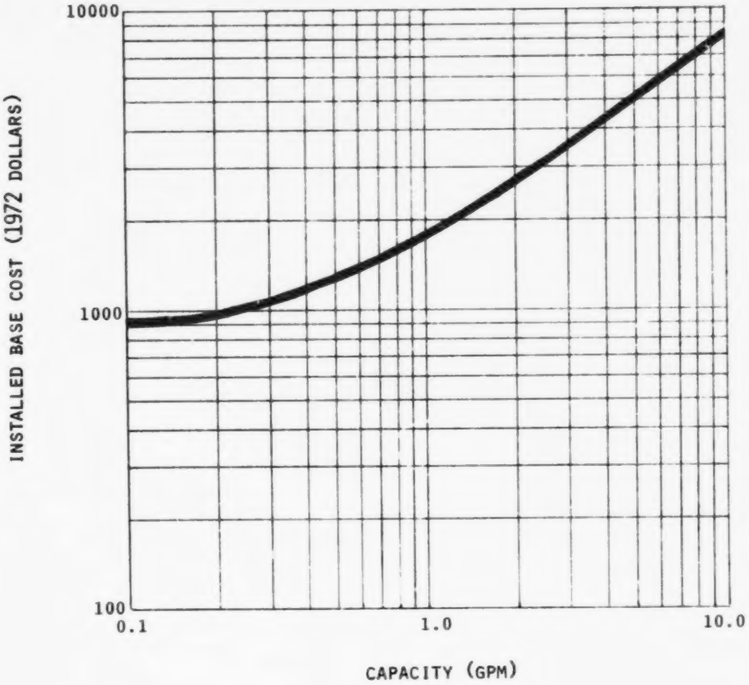
INDUSTRY GROUP	DEPRECIATION RATE (percent)	EXPECTED LIFETIME (years)
Heavy Chemical	0.071-0.091	11-14
Oil and Gas Refining	0.063-0.071	14-16
Resins and Polymers	0.071	14
Food and Beverage	0.056- .083	12-18
Pulp and Paper	0.063	16
Mining	0.063-0.100	10-18

US-1

ULTRAFILTRATION SYSTEM

ULTRAFILTRATION SYSTEM





REGIONAL ADJUSTMENT

Region	F_R
1	1.000
2	1.064
3	0.978
4	1.034
5	1.076
6	1.027
7	1.066
8	1.029
9	1.067
10	1.033

Installed ultrafiltration system cost includes purchased cost of membrane modules, membranes, pressurization pump, recirculation pump, handling and setting, piping, concrete, steel, instrumentation, electrical, paint, and indirect costs (prime contractor engineering and construction overhead).

INSTALLED ULTRAFILTRATION SYSTEM COST,\$ = (INSTALLED BASE COST)(F_R)

ANNUAL MAINTENANCE

Annual maintenance will be approximately 1 to 3 percent of installed ultrafiltration system cost.

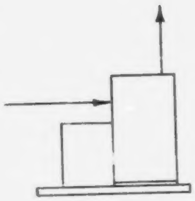
OPERATION COST

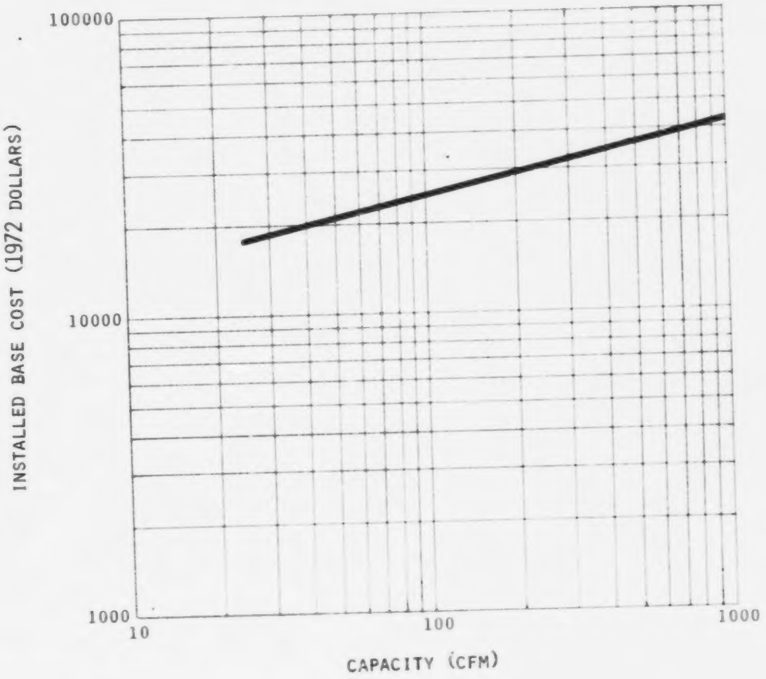
Ultrafiltration systems require no operator attention.

PROBABLE ANNUAL DEPRECIATION RATE

INDUSTRY GROUP	DEPRECIATION RATE (percent)	EXPECTED LIFETIME (years)
Heavy Chemical	0.050-0.091	11-20
Oil and Gas Refining	0.045	22
Resins and Polymers	0.045	22
Food and Beverage	0.045	22
Pulp and Paper	0.045	22
Mining	0.045	22

VACUUM PUMP





REGIONAL ADJUSTMENT

Region	F_R
1	1.000
2	1.073
3	0.979
4	1.038
5	1.084
6	1.025
7	1.062
8	1.039
9	1.069
10	1.031

Installed vacuum pump cost includes purchased cost of vacuum pump, motor and drive, handling and setting, piping, concrete, instrumentation, electrical, insulation, paint, and indirect costs (prime contractor engineering and construction overhead).

INSTALLED VACUUM PUMP COST,\$ = (INSTALLED BASE COST)(F_R)

ANNUAL MAINTENANCE

Annual maintenance will be approximately 0.75 percent of the installed vacuum pump cost.

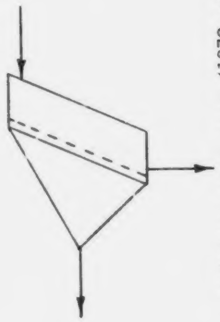
OPERATION COST

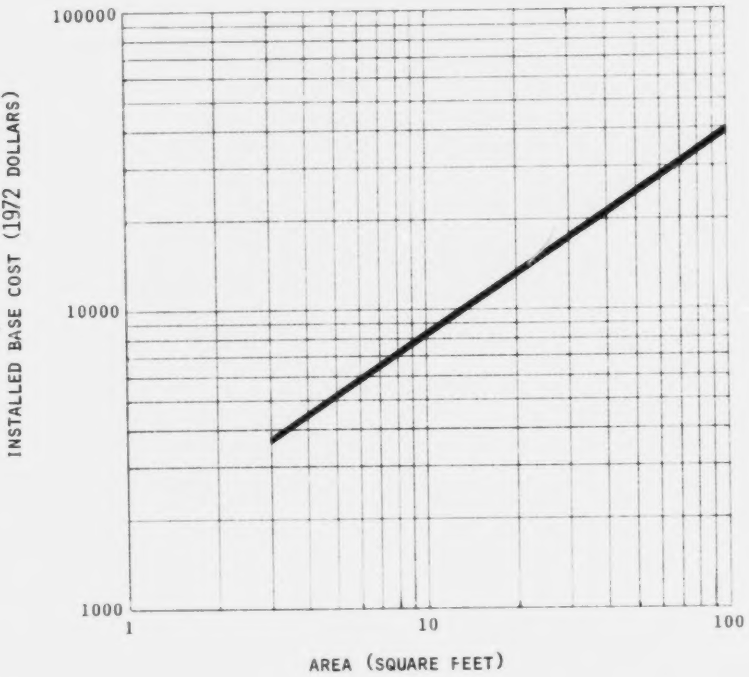
Vacuum pumps require no operator attention.

PROBABLE ANNUAL DEPRECIATION RATE

INDUSTRY GROUP	DEPRECIATION RATE (percent)	EXPECTED LIFETIME (years)
Heavy Chemical	0.05-0.091	11-20
Oil and Gas Refining	0.063-0.071	14-16
Resins and Polymers	0.071-0.111	9-14
Food and Beverage	0.056-0.091	11-18
Pulp and Paper	0.063-0.100	10-16
Mining	0.063-0.100	10-18

VIBRATING SCREEN





DESIGN ADJUSTMENT

Type	F_D
Single Deck	1.000
Two Deck	1.192
Three Deck	1.436

REGIONAL ADJUSTMENT

Region	F_R
1	1.000
2	0.996
3	0.897
4	1.034
5	1.193
6	1.049
7	1.047
8	1.098
9	1.057
10	1.009

Installed vibrating screen cost includes purchased cost of vibrating screen motor and drive, handling and setting, piping and ductwork, concrete, instrumentation, electrical, paint, and indirect costs (prime contractor engineering and construction overhead).

INSTALLED VIBRATING SCREEN COST, $ = (INSTALLED BASE COST)$(F_D)(F_R)$

ANNUAL MAINTENANCE

Annual maintenance will be approximately 1.87 percent of installed vibrating screen cost and will depend upon material corrosivity and abrasiveness.

OPERATION COST

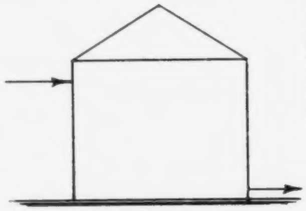
Vibrating screens require no operator attention.

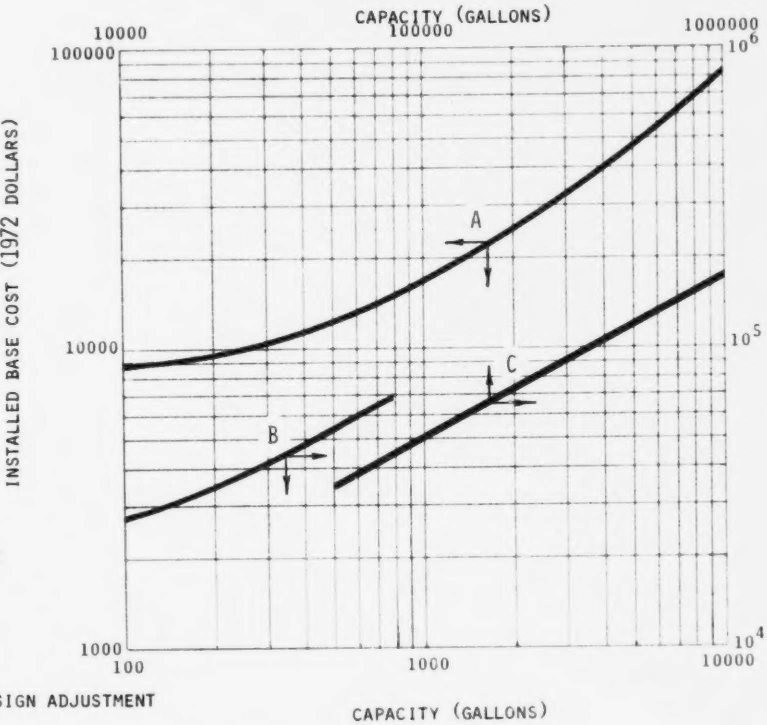
PROBABLE ANNUAL DEPRECIATION RATE

INDUSTRY GROUP	DEPRECIATION RATE (percent)	EXPECTED LIFETIME (years)
Heavy Chemical	0.05-0.091	11-20
Oil and Gas Refining	0.063-0.071	14-16
Resins and Polymers	0.071-0.111	9-14
Food and Beverage	0.056-0.091	11-18
Pulp and Paper	0.063-0.100	10-16
Mining	0.063-0.100	10-18

VERTICAL TANK

VERTICAL TANK





DESIGN ADJUSTMENT

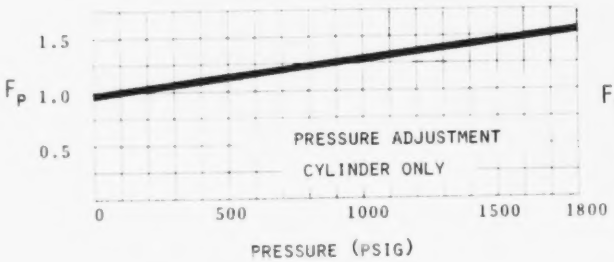
Type	Curve	F_D	Pressure (PSIG)
Gas Holder	A	0.920	--
Jacketed	A	1.250	--
Cylindrical	A	1.000	50
Cone Roof	C	1.000	--
Lifter Roof	C	1.099	--
Floating Roof	C	1.023	--
API Conical	C	1.057	--
Sphere	C	1.920	--
Spheroid	C	1.322	--
Jacket Vacuum	B	2.830	--
Vacuum	B	1.000	--

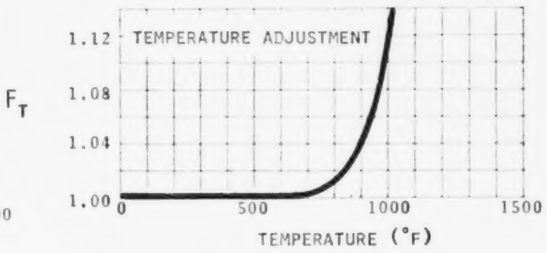
MATERIAL ADJUSTMENT

Material	F_M
CS	1.000
Al	1.361
Ti	1.449
Monel	1.280
Ni	1.342
Glass Lined CS	1.879
Cu	1.237
Moly	1.599
SS304	1.068
SS316	1.112
A 204 CS	1.006

REGIONAL ADJUSTMENT

Region	F_R
1	1.000
2	1.061
3	0.984
4	1.032
5	1.073
6	1.024
7	1.062
8	1.024
9	1.065
10	1.031





Installed vertical tank cost includes purchased cost of vertical tank (field erection for large size vessels), handling and setting, piping, concrete, instrumentation, insulation, paint, and indirect costs (prime contractor engineering and construction overhead).

INSTALLED VERTICAL TANK COST, $ = (INSTALLED BASE COST)$(F_D)(F_M)(F_P)(F_R)(F_T)$

ANNUAL MAINTENANCE

Annual maintenance will vary from 1.93 - 2.61 percent of installed vertical tank cost and will depend upon temperature, pressure, fluid corrosivity and cycle time.

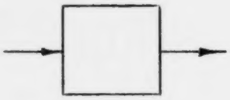
OPERATION COST

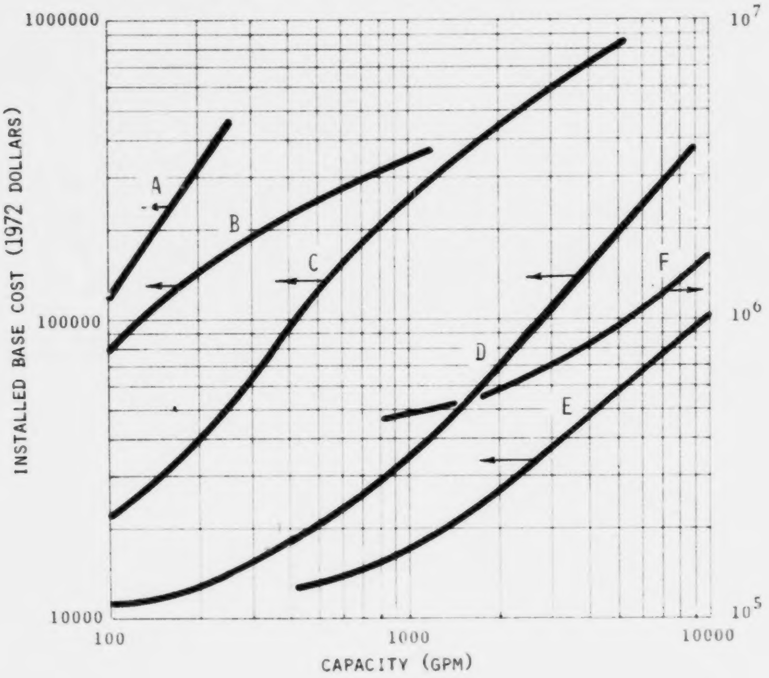
Vertical tanks require no operator attention.

PROBABLE ANNUAL DEPRECIATION RATE

INDUSTRY GROUP	DEPRECIATION RATE (percent)	EXPECTED LIFETIME (years)
Heavy Chemical	0.050-0.091	11-20
Oil and Gas Refining	0.045	22
Resins and Polymers	0.045	22
Food and Beverage	0.045	22
Pulp and Paper	0.045	22
Mining	0.045	22

WATER TREATMENT SYSTEM





DESIGN ADJUSTMENT

Type	Curve	F_D
Demineralizing System	A	1.00
Softening System	B	1.000
Filtering System	C	1.000
Pumping Station	D	1.000
Cooling System	E	1.000
Outfall System (10000 ft)	F	1.000

REGIONAL ADJUSTMENT

Region	F_R
1	1.000
2	1.045
3	0.947
4	1.043
5	1.133
6	1.041
7	1.066
8	1.065
9	1.067
10	1.029

Installed water treatment system cost includes purchased cost of water treatment system, pumps, drives, necessary closed pump station buildings (if required), handling and setting, piping, concrete, basins, pits and foundations, steel, instrumentation, electrical, paint, and indirect costs (prime contractor engineering and construction overhead).

INSTALLED WATER TREATMENT SYSTEM COST, $\$ = (\text{INSTALLED BASE COST})(F_D)(F_R)$

ANNUAL MAINTENANCE

Annual maintenance will vary from 0.1 to 8 percent of installed water treatment system cost and will primarily depend upon influent water quality, flowrate, and cycling.

OPERATION COST

Water treatment systems require between 0.125 and 1.0 operators per shift.

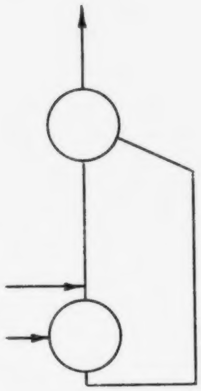
PROBABLE ANNUAL DEPRECIATION RATE

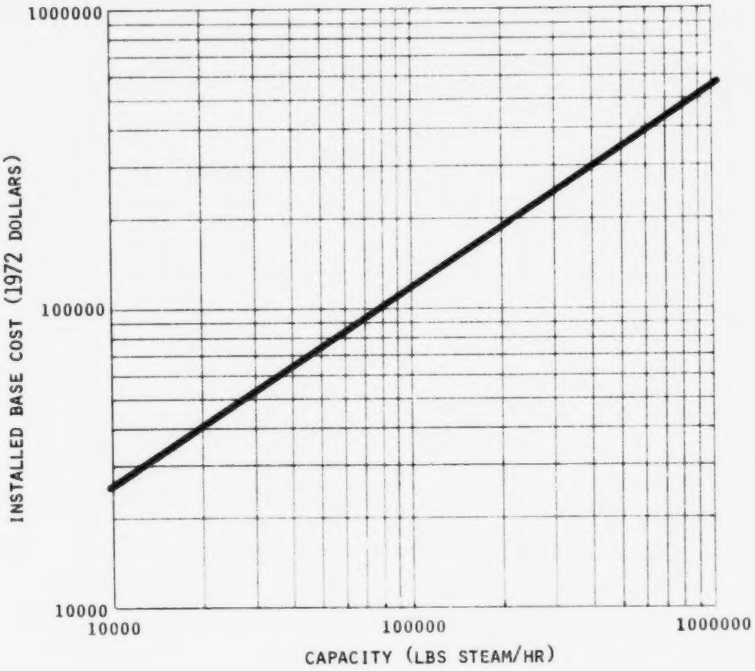
INDUSTRY GROUP	DEPRECIATION RATE (percent)	EXPECTED LIFETIME (years)
Heavy Chemical	0.016-0.040	25-60
Oil and Gas Refining	0.016-0.040	25-60
Resins and Polymers	0.016-0.040	25-60
Food and Beverage	0.016-0.040	25-60
Pulp and Paper	0.016-0.040	25-60
Mining	0.016-0.040	25-60

WTS-3

STEAM BOILER

STEAM BOILER





REGIONAL ADJUSTMENT

Region	F_R
1	1.000
2	1.044
3	0.979
4	1.030
5	1.069
6	1.015
7	1.051
8	1.034
9	1.051
10	1.024

Installed steam boiler cost includes purchased cost of boiler, forced draft fans, burners, soot blowers, boiler feedwater pumps, feed water deaerator, chemical injection system, stock, handling and setting, piping, concrete, steel, instrumentation, electrical, insulation, paint, and indirect costs (prime contractor engineering and construction overhead).

INSTALLED STEAM BOILER COST, \$ = (INSTALLED BASE COST)(F_D) (F_R)

ANNUAL MAINTENANCE

Annual maintenance will be approximately 3 percent of installed steam boiler cost.

OPERATION COST

Steam boilers require between 0.125 and 1.0 operators per shift.

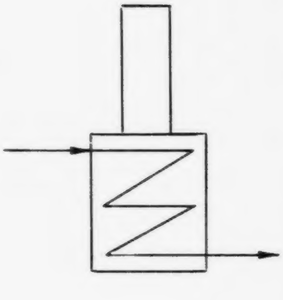
PROBABLE ANNUAL DEPRECIATION RATE

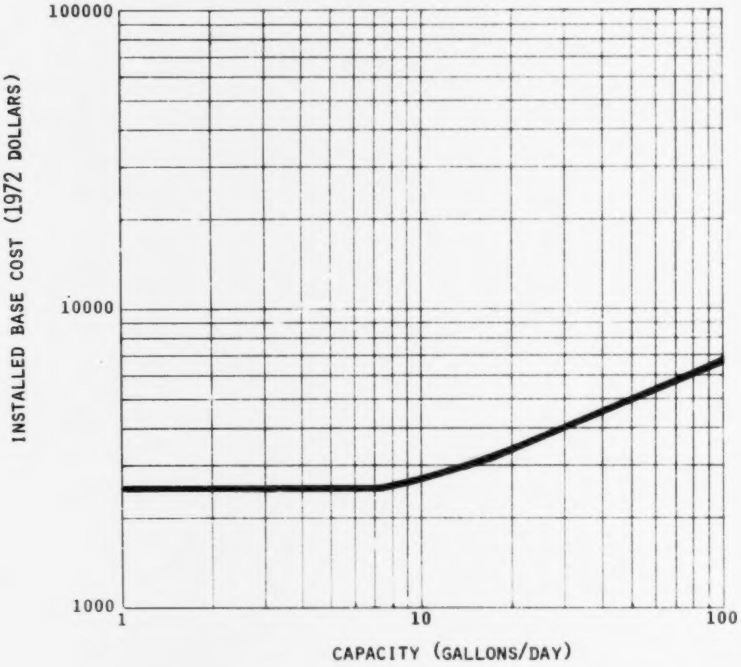
INDUSTRY GROUP	DEPRECIATION RATE (percent)	EXPECTED LIFETIME (years)
Heavy Chemical	0.071-0.091	11-14
Oil and Gas Refining	0.063-0.071	14-16
Resins and Polymers	0.071-0.111	9-14
Food and Beverage	0.056-0.083	12-18
Pulp and Paper	0.063	16
Mining	0.100	10

WTS-5

WATER STILL

WATER STILL





REGIONAL ADJUSTMENT

Region	F_R
1	1.000
2	1.044
3	0.979
4	1.030
5	1.069
6	1.015
7	1.051
8	1.034
9	1.051
10	1.024

Installed water still cost includes purchased cost of still, handling and setting, piping, concrete, steel, instrumentation, insulation, paint, and indirect costs (prime contractor engineering and construction overhead).

INSTALLED WATER STILL COST,\$ = (INSTALLED BASE COST) (F_R)

ANNUAL MAINTENANCE

Annual maintenance will be approximately 3 percent of installed water still cost.

OPERATION COST

Water stills require between 0.05 and 0.2 operators per shift.

PROBABLE ANNUAL DEPRECIATION RATE

INDUSTRY GROUP	DEPRECIATION RATE (percent)	EXPECTED LIFETIME (years)
Heavy Chemical	0.050-0.091	11-20
Oil and Gas Refining	0.045	22
Resins and Polymers	0.045	22
Food and Beverage	0.045	22
Pulp and Paper	0.045	22
Mining	0.045	22

SECTION IV

ACKNOWLEDGEMENTS

This project was directed by Mr. Herbert G. Blecker. Assistance in this effort by many individuals in and out of government has been extremely helpful. We especially acknowledge those vendors and contractors who have assisted in the effort. We are grateful for the guidance provided by Mr. Paul Greenberger and other members of the Environmental Protection Agency Staff.

SECTION V

REFERENCES

1. Blecker, H. G. and Nichols, T. M., *CØST® System User's Manual*, Second Edition, ICARUS Corporation, Silver Spring, Maryland, January 1973.

2. Blecker, H. G., *From Process Flowsheet to Detailed Estimate*, presented at the American Institute of Chemical Engineers 18th Annual All-Day Meeting, University of Delaware, March 27, 1973.

3. Blecker, H. G., *Computer Simulation of Definitive Estimates*, to be presented at the National Meeting of the American Association of Cost Engineers, St. Louis, Mo., June 1973.

4. Blecker, H. G., Cost Models: *A Computerized Approach to the Simulation of Equipment Cost*, 1972 Transactions of the American Association of Cost Engineers.

5. Blecker, H. G., *Simulation of Chemical Processing Plant Investment by Computer*, 1972 Transactions of the Summer Computer Simulation Conference, San Diego, California, June 14-16, 1972.

6. U.S. Department of Commerce, *Selected Climatic Maps of the United States*, U.S. Government Printing Office, Washington, D.C., 1966.

7. Foster, N., *1972 Dodge Construction and Scheduling Manual*, McGraw-Hill Information Systems Company, New York, N.Y., 1972.

8. McKee-Berger-Mansueto Inc., *Building Cost File*, Construction Publishing Company, Inc., New York, N.Y., 1973.

9. Rase, H. F., and Barrow, M.H., *Project Engineering of Process Plants*, John Wiley and Sons, Inc., New York, N.Y., May 1967.

10. Ludwig, E. E., *Applied Process Design for Chemical and Petrochemical Plants, Vol. I-III*, Gulf Publishing Company, Houston, Texas, 1964.

SECTION VI

GLOSSARY

Adjustment Factor - An additive or multiplicative factor for adjusting installed base cost to obtain installed cost. The adjustments may be regional (for location of installation), design (for the type of design), pressure, temperature, cost escalation, or other pertinent parameters.

Cost Escalation Factor - See Adjustment Factor, a composite of the Marshall & Stevens Index and the Engineering News Record Construction Cost Index.

Design Adjustment Factor - See Adjustment Factor.

Equipment Item - A piece of processing equipment. Generally refers to the piece as purchased and before installation.

Installed Base Cost - The installed cost for an equipment module in a nominal location with nominal design and operating characteristics.

Installed Cost - The cost including purchased equipment, material and labor requirements for installation, contractors engineering and overhead. For processes, includes contractors fee, contingencies, and land cost as well.

Installed Equipment Module - An equipment item together with its usual accessories, all completely installed.

Key Cost Parameter - The single physical or capacity characteristic of an installed equipment module which is most directly related to installed cost.

Labor to Material Ratio - The ratio of labor to material requirements in installed equipment module.

Pressure Adjustment Factor - See Adjustment Factor.

Regional Adjustment Factor - See Adjustment Factor.

Subcontract Cost - The fee paid to another by the contractor for services, such as erecting a building, completing yard improvements, etc.

Temperature Adjustment Factor - See Adjustment Factor.

Additional glossaries may be found in

1. Industrial & Engineering Chemistry 52 (6), 69 (1960).
2. Industrial & Engineering Chemistry 52 (7), 53 (960).
3. J. H. Perry, Chemical Engineers' Handbook, 4th Ed., pages 26-2, to 26-5.

SECTION VII

APPENDICES

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B. Regional Data 165

C. Frost Depth 166

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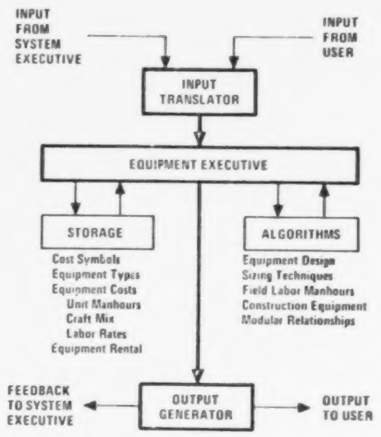
APPENDIX A

COST MODULES

EQUIPMENT COST ELEMENT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Craft Mix
Labor Rates
Equipment Rental
ALGORITHMS
Equipment Design
Sizing Techniques
Field Labor Manhours
Construction Equipment
Modular Relationships
FEEDBACK TO SYSTEM EXECUTIVE
OUTPUT GENERATOR
OUTPUT TO USER

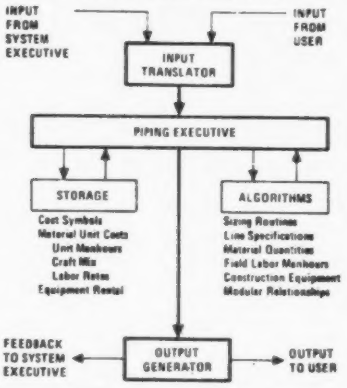
Material Component

All equipment necessary for the processing plant as indicated on flowsheets, equipment lists, etc.

Labor Component

All labor operations necessary to unload, store, set in place, erect and test process equipment on the job site. Includes labor to assemble, erect and dismantle rigging poles and guy derricks when necessary.

PIPING COST ELEMENT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Craft Mix
Labor Rates
Equipment Rental
ALGORITHMS
Sizing Routines
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Material Quantities
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Construction Equipment
Modular Relationships
FEEDBACK TO SYSTEM EXECUTIVE
OUTPUT GENERATOR
OUTPUT TO USER

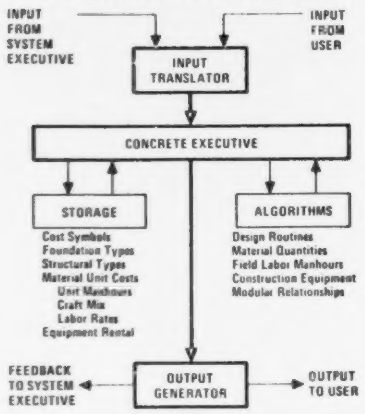
Material Component

- Shop fabricated material – process, auxiliary, utility
- Field fabricated material – process, auxiliary, utility
- Field assembly material (valves, flanges, expansion joints, etc.)
- Small piping under 2" (screwed, socket in weld, steam tracing, tubing, valves, etc.)
- Underground piping (cast iron, vitrified clay, concrete transite, etc.)
- Special fabricated systems (rubber lined, glass lined, etc., as required by a particular process)
- Shoes, guides, brackets, clamps, hangers, insulation supports, etc.
- Scaffolding as required

Labor Component

- Unload, store, handle
- Field fabrication (all labor operations performed in the jobsite weld shop such as cutting/beveling, preheating, welding, x-ray, stress relief, etc.)
- Pipe erection (all labor operations to erect shop fabricated and field fabricated spools in place, install pipe, valves, and other assembly material, coat and wrap underground piping, stress relief and x-ray field welds, etc.)
- Small piping under 2" (all labor operations to install screwed, socket weld, steam tracing, tubing, etc.)
- Special fabricated systems (all labor operations necessary to install rubber lined, glass lined and other special prefabricated components)
- Labor manhours to install shoes, hangers, guides, brackets, etc., necessary to support piping systems
- Scaffolding labor as required

CONCRETE COST ELEMENT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Labor Rates
Equipment Rental
ALGORITHMS
Design Routines
Material Quantities
Field Labor Manhours
Construction Equipment
Modular Relationships
FEEDBACK TO SYSTEM EXECUTIVE
OUTPUT GENERATOR
OUTPUT TO USER

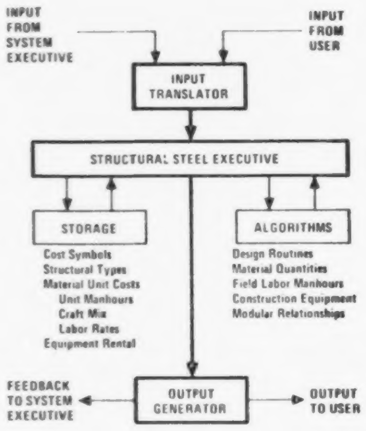
Material Component

- Concrete (redi-mix, cement, sand, aggregate add mix., color, testing, etc.)
- Forming (plywood, sonotube, metal forms, backup lumber, nails, clamps, etc.)
- Reinforcing (rebar, tie wire, mesh, etc.)
- Accessories (anchor bolts, curb angles, fireproofing material, hardware, etc.)
- Concrete pipe supports and sleepers
- Miscellaneous (trench covers, basin covers, manholes, catch basins, manholes, etc.)
- Weather protection (shelters, heating equipment, covers, etc.)
- Scaffolding as required

Labor Component

- Unload, store, handle
- Equipment foundations (all labor operations necessary to install rebar, forming and mass pour concrete)
- Pipe supports (all labor operations to install precast supports, sleepers, poured in place items, etc.)
- Basins, manholes, trenches (all labor operations to install cooling tower basins, manholes, catch basins, pull boxes, valve boxes, trenches, etc.)
- Concrete paving (all labor operations necessary to install paving, roads, gutters, envelopes, etc.)
- Miscellaneous (all labor required to grout and finish equipment setting, apply special coatings to foundation slabs, basins, etc.)
- Scaffolding labor as required

STRUCTURAL STEEL COST ELEMENT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Structural Types
Material Unit Costs
Unit Manhours
Craft Mix
Labor Rates
Equipment Rental
ALGORITHMS
Design Routines
Material Quantities
Field Labor Manhours
Construction Equipment
Modular Relationships
FEEDBACK TO SYSTEM EXECUTIVE
OUTPUT GENERATOR
OUTPUT TO USER

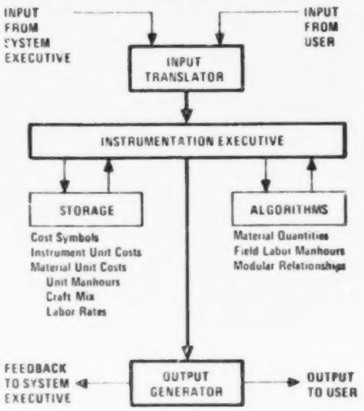
Material Component

- Steel structures (for process equipment access and support, including ladders, platform walkways, guard rails, crane rails, all apperienances, etc.)
- Ladders, platforms, and walkways (when not attached to vessels, boilers, and coolers, etc.)
- Steel pipe supports and sleepers
- Scaffolding as required

Labor Component

- Unload, store, handle
- Steel structures (all labor operations to erect steel structures on the jobsite)
- Ladders and platforms (all labor operations to erect on the jobsite)
- Steel pipe supports (all labor to assemble, erect or install on the jobsite)
- Scaffolding labor as required

INSTRUMENTATION COST ELEMENT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Unit Manhours
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Labor Rates
ALGORITHMS
Material Quantities
Field Labor Manhours
Modular Relationships
FEEDBACK TO SYSTEM EXECUTIVE
OUTPUT GENERATOR
OUTPUT TO USER

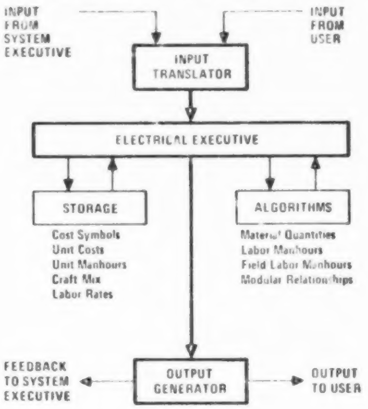
Material Component

- Major offline items (analyzers, etc.)
- Sensing devices (temperature, pressure, flow, gauge glasses, level indicators, etc.)
- Control devices (control valves, power operators, etc.)
- Miscellaneous (relief valves, steam traps, switches, alarms, solenoids, etc.)
- Field assembly material (piping, tubing, supports, tube racks, etc.)
- Control panels and panel mounted instruments
- Scaffolding as required

Labor Component

- Unload, store, handle
- Major offline items (all labor operations necessary to install analyzers, etc.)
- Local instruments (all labor operations necessary to install sensing and control instruments in the field)
- Miscellaneous (all labor operations necessary to install relief valves, steam traps, switches, alarms, solenoids, etc.)
- Field assembly (all labor operations to install main control tubing runs, etc.)
- Check out, calibrate, and test
- Scaffolding labor as required

ELECTRICAL COST ELEMENT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ALGORITHMS
Material Quantities
Labor Manhours
Field Labor Manhours
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FEEDBACK TO SYSTEM EXECUTIVE
OUTPUT GENERATOR
OUTPUT TO USER

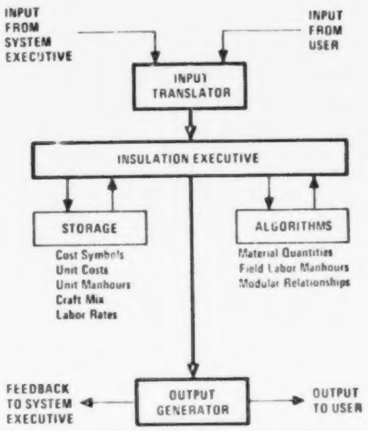
Material Component

- Power distribution and control (substations, switchgear, motor control centers, transformers, circuit breakers, starters, bus ducts, etc.)
- Power feeders and motor runs (raceway systems, cable conduit, associated accessories, etc.)
- Lighting (transformers, panels, contactors, transfer switches, wire, conduit support systems, floodlights, street lights, etc.)
- Grounding and Cathodic Protection
- Instrumentation (all equipment and material for instrumentation systems such as level, pressure, flow recorder signal transmission, thermocouple extensions, alarms, interlock systems, etc.)
- Communications (telephone systems, intercom loud speakers, fire reporting systems, etc.)
- Pole lines (pole mounted installation for power distribution, motor runs, lighting, instrumentation, communication, etc.)
- Scaffolding as required

Labor Component

- Unload, store, handle
- Power distribution and control (All labor operations necessary to install major items of electrical equipment. This includes handling, storing, setting in place and testing.)
- Conduit work (all labor operations necessary to install conduit and accessories for power feeders and motor runs, both above and below ground level)
- Wire and cable (all labor operations necessary to install wire and cable for power feeders and motor runs both above and below ground level, instrumentation, communications, etc.). Test and check out.
- Pole lines (all labor operations necessary to install wood poles, set and dress, install conductors, etc.). Test and check out.
- Scaffolding labor as required

INSULATION COST ELEMENT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ALGORITHMS
Material Quantities
Field Labor Manhours
Modular Relationships
FEEDBACK TO SYSTEM EXECUTIVE
OUTPUT GENERATOR
OUTPUT TO USER

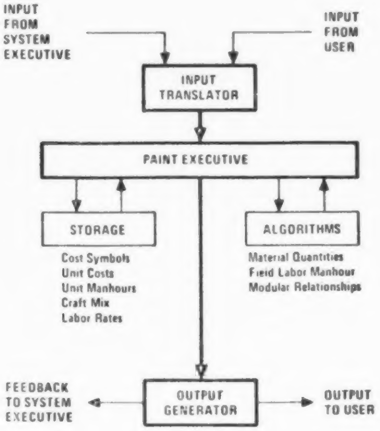
Material Component

- Equipment insulation material (special molding, covers, flat sheets, etc.)
- Piping insulation material, molded pipe insulation, covers, flange covers, etc.
- Tiewire, mesh, etc.
- Scaffolding as required

Labor Component

- Unload, store and handle
- All labor operations to install insulation on equipment items and piping as required
- Scaffolding labor as required

PAINT COST ELEMENT


INPUT FROM SYSTEM EXECUTIVE
INPUT FROM USER
INPUT TRANSLATOR
PAINT EXECUTIVE
STORAGE
Cost Symbols
Unit Costs
Unit Manhours
Craft Mix
Labor Rates
ALGORITHMS
Material Quantities
Field Labor Manhour
Modular Relationships
FEEDBACK TO SYSTEM EXECUTIVE
OUTPUT GENERATOR
OUTPUT TO USER

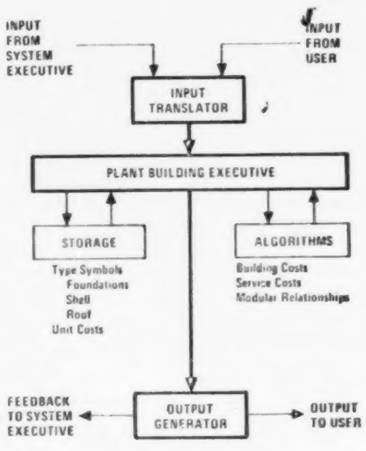
Material Component

- Paint material, special coatings, etc.
- Sandblasting material as required
- Scaffolding as required

Labor Component

- Unload, store, and handle
- Labor to apply paint (spray, brush, etc.)
- Scaffolding labor as required

PLANT BUILDING COST ELEMENT


INPUT FROM SYSTEM EXECUTIVE
INPUT FROM USER
INPUT TRANSLATOR
PLANT BUILDING EXECUTIVE
STORAGE
Type Symbols
Foundations
Shell
Roof
Unit Costs
ALGORITHMS
Building Costs
Service Costs
Modular Relationships
FEEDBACK TO SYSTEM EXECUTIVE
OUTPUT GENERATOR
OUTPUT TO USER

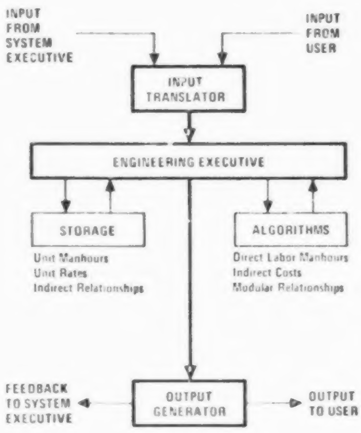
Material Component

All material necessary to construct buildings as required (administration, workshops, control rooms, steel structures, etc.)

Labor Component

All labor necessary to construct buildings as required (plus burden and overhead if buildings subcontracted)

ENGINEERING COST ELEMENT


INPUT FROM SYSTEM EXECUTIVE
INPUT FROM USER
INPUT TRANSLATOR
ENGINEERING EXECUTIVE
STORAGE
Unit Manhours
Unit Rates
Indirect Relationships
ALGORITHMS
Direct Labor Manhours
Indirect Costs
Modular Relationships
FEEDBACK TO SYSTEM EXECUTIVE
OUTPUT GENERATOR
OUTPUT TO USER

Material Component

All monies to cover the following home office indirect costs

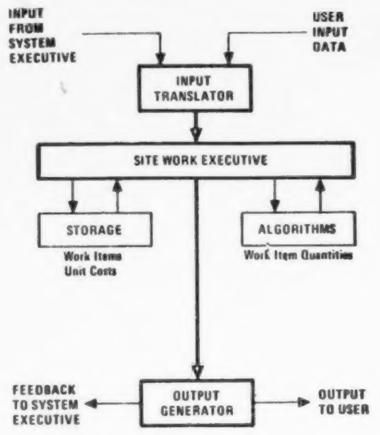
- Payroll burdens
- Office expense
- Office overhead

Labor Component

All home office labor for the following engineering activities

- Project
- Process
- Design
- Procurement
- Home Office Construction

SITE WORK COST ELEMENT


INPUT FROM SYSTEM EXECUTIVE
USER INPUT DATA
INPUT TRANSLATOR
SITE WORK EXECUTIVE
STORAGE
Work Items
Unit Costs
ALGORITHMS
Work Item Quantities
FEEDBACK TO SYSTEM EXECUTIVE
OUTPUT GENERATOR
OUTPUT TO USER

Material Component

All material and equipment necessary for site work:

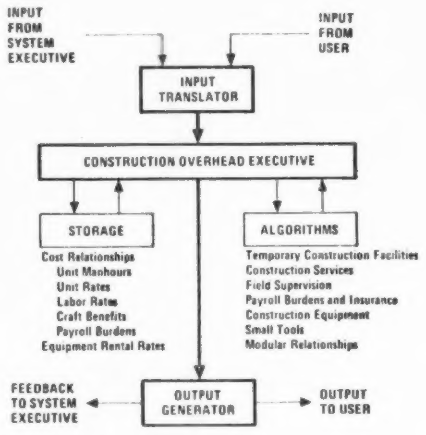
- Roads, walkways, paving
- Site clearing, excavation and grading
- Sewers and underground
- Landscaping, etc.

Labor Component

All labor necessary for site work:

- Roads, walkways, paving
- Site clearing, excavation and grading
- Sewers and underground
- Landscaping, etc.

CONSTRUCTION OVERHEAD COST ELEMENT


INPUT FROM SYSTEM EXECUTIVE
INPUT FROM USER
INPUT TRANSLATOR
CONSTRUCTION OVERHEAD EXECUTIVE
STORAGE
Cost Relationships
Unit Manhours
Unit Rates
Labor Rates
Craft Benefits
Payroll Burdens
Equipment Rental Rates
ALGORITHMS
Temporary Construction Facilities
Construction Services
Field Supervision
Payroll Burdens and Insurance
Construction Equipment
Small Tools
Modular Relationships
FEEDBACK TO SYSTEM EXECUTIVE
OUTPUT GENERATOR
OUTPUT TO USER

Material Component

- All material necessary to construct temporary facilities
- Payroll burdens and expense on direct and indirect field labor and supervision
- Construction equipment rental and small tool cost

Labor Component

- All labor necessary to construct temporary facilities and provide construction services in the field
- All field staff labor and costs

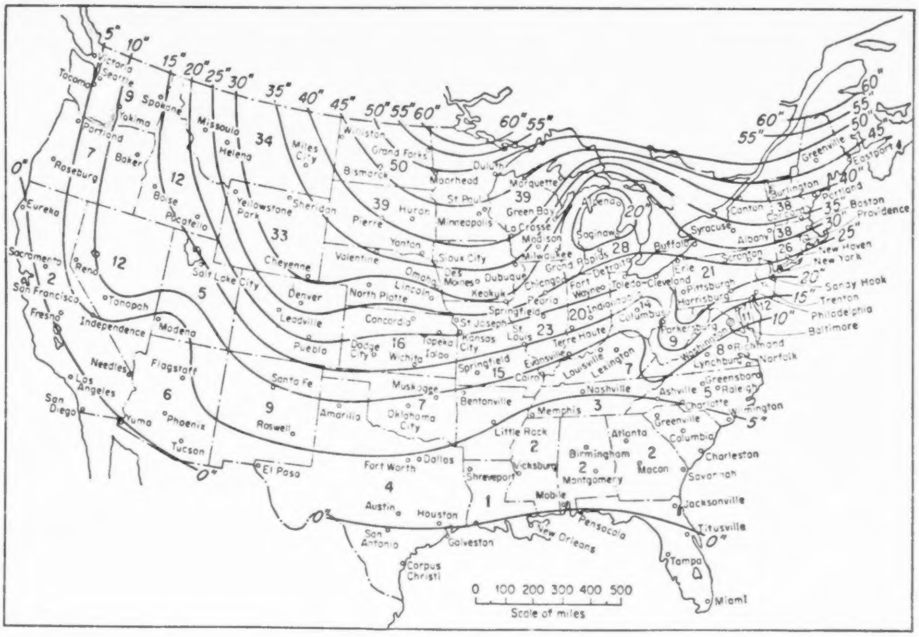
APPENDIX B

REGIONAL DATA

REGION	WIND SPEED RANGE (MPH)	FROST LINE RANGE (INCHES)	SOIL TYPE	SOIL LOADING (LBS/FT^3)	SOIL DENSITY (LBS/FT^3)	AVERAGE UNLOADED FIELD LABOR WAGE RATE ($/MH)	SHOP FABRICATION VS. FIELD ERECTION (FT DIA)
1	67-100	25-60	DRY SAND	6000	100	6.08	13.5
2	67-100	15-45	SAND	8000	90	8.68	13.5
3	67-90	10-25	DRY SAND	6000	100	5.55	13.5
4	67-120	0-10	DRY SAND	3000	90	6.88	13.5
5	67-100	10-60	DRY SAND	4000	90	8.61	14.5
6	67-100	0-15	DRY SAND	3000	90	6.89	15.0
7	67-100	10-45	DRY SAND	4000	90	8.23	15.0
8	75-100	5-60	DRY SAND	4000	90	6.81	15.0
9	60-90	0-10	DRY SAND	4000	90	6.45	14.5
10	60-95	0-25	DRY SAND	4000	90	7.17	14.5

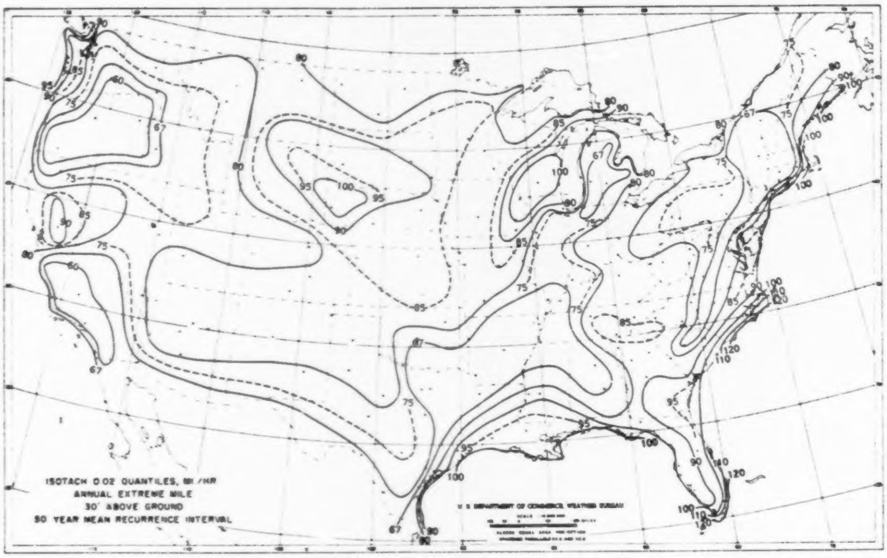
APPENDIX C

FROST DEPTH


5"
10"
15"
20"
25"
30"
35"
40"
45"
50"
55"
60"
60"
55"
0"
Victoria
Seattle
Tacoma
9
Spokane
Yakima
Portland
7
Baker
Roseburg
Missoula
Helena
34
Miles City
Williston
Grand Forks
50
Bismarck
Moorhead
Duluth
Marquette
39
12
Boise
Pocatello
Yellowstone Park
Sheridan
39
Pierre
Huron
St Paul
Minneapolis
Green Bay
La Crosse
Alpena
20"
Eureka
33
Yankton
Madison
Saginaw
Sacramento
Reno
12
Cheyenne
Valentine
Sioux City
Milwaukee
Grand Rapids
28
Buffalo
Syracuse
Canton
38
Burlington
Greenville
Eastport
60"
55"
50"
45"
40"
Portland
35"
Boston
Providence
30"
25"
Concord
Albany
38
26
New Haven
New York
Scranton
2
San Francisco
Tonopah
Salt Lake City
5
Denver
North Platte
Omaha
Lincoln
Des Moines
Dubuque
Keokuk
Chicago
Fort Wayne
Detroit
Toledo
Cleveland
Erie
21
Pittsburgh
Harrisburg
20"
Sandy Hook
15"
Trenton
Philadelphia
10"
Baltimore
Fresno
Independence
Modena
Leadville
Concordia
St Joseph
Springfield
Peoria
20
Indianapolis
Columbus
14
12
11
Pueblo
Dodge City
16
Wichita
Topeka
Iolao
Kansas City
St Louis
23
Terre Haute
Parkersburg
9
Washington
8
Richmond
Lynchburg
Norfolk
Needles
Flagstaff
Springfield
15
Cairo
Evansville
Louisville
Lexington
7
Greensboro
Raleigh
5
Ashville
Los Angeles
San Diego
6
Santa Fe
Muskogee
7
Bentonville
Nashville
3
Memphis
Charlotte
Wilmington
5"
Yuma
Phoenix
9
Roswell
Amarillo
Oklahoma City
Little Rock
2
Atlanta
Greenville
Columbia
Tucson
0"
El Paso
Fort Worth
Dallas
Birmingham
2
2
Macon
Charleston
Vicksburg
Montgomery
Savannah
Shreveport
4
Austin
Houston
1
Mobile
Jacksonville
0"
San Antonio
Galveston
New Orleans
Pensacola
Titusville
0"
Corpus Christi
Tampa
Miami
0 100 200 300 400 500
Scale of miles

APPENDIX D

ISOTACH


ISOTACH 0.02 QUANTILES, MI/HR
ANNUAL EXTREME MILE
30' ABOVE GROUND
50 YEAR MEAN RECURRENCE INTERVAL
U S DEPARTMENT OF COMMERCE, WEATHER BUREAU

APPENDIX E

SELECTED MATERIAL COSTS

The following table lists some approximate prices for equipment item materials of construction.

MATERIAL	APPROXIMATE COST* BASE MATERIAL ($/lb)
ALUMINUM	0.40 - 0.60
BERYLLIUM	500.00
BRASS	0.90
BRONZE	0.95
CARBON STEEL	0.07 - .11
COLUMBIUM	50.00
COPPER	1.00
CUPRONICKEL	1.20
GOLD	500.00
MAGNESIUM	0.70 - 2.00
MOLYBDENUM	30.00
MONEL	1.90
MUNTZ	0.85
NICKEL	2.20
PALLADIUM	550.00
PLATINUM	1800.00
RHODIUM	3000.00
SILVER	24.00
STAINLESS STEEL	0.25 - 1.20
TANTALUM	70.00
TIN	1.70
TITANIUM	2.00 - 4.00
ZINC	0.25
ZIRCONIUM	16.00

*3RD QUARTER 1972

APPENDIX F

CROSS REFERENCE INDEX

TO FIND	LOOK UNDER	IN SECTION
	A	
ABSORBENTS	SEE ADSORBENTS	
ABSORBERS/ABSORPTION TOWERS	SEE COLUMNS	
ABSORBERS	SEE PACKED COLUMNS, ION EXCHANGERS, PACKINGS	-
ABSORBER-CONCENTRATOR	PACKED COLUMN	TW
	PACKING	TW
ACCUMULATORS	SEE RECEIVER, VESSEL	-
ACID EGGS	SEE VESSELS, REACTORS, TANKS	-
ACIDULATORS	SEE REACTORS, VESSELS	-
ADSORBENTS	PACKING	TW
	ION EXCHANGER	IE
ADSORPTION COLUMN	PACKED COLUMN	TW
	TRAY TOWER	TW
	PACKING	TW
AFTERCOOLERS	HEAT EXCHANGER	HE
AGGLOMERATORS	SEE KILNS, MILLS	-
AGITATED KETTLE	AGITATED OPEN TANKS	AOT
	AGITATED PRESSURE TANKS	APT
	SEE ALSO REACTORS	-
AGITATED OPEN TANKS	MIXER TANK	AOT
	OPEN TOP TANK	AOT
	SEE ALSO VESSELS, REACTORS	-
AGITATED PRESSURE TANKS	AUTOCLAVE	APT
	REACTOR	APT
	SEE ALSO VESSELS, REACTORS	-
AGITATED VESSELS	AGITATED OPEN TANK	AOT
	AGITATED PRESSURE TANK	APT
	SEE ALSO AGITATORS, BLENDERS, MIXERS, KNEADERS, TRAY DRYING SYSTEMS, DRYERS, ROTARY DRYERS, MILLS	- -
AIR-CONDITIONERS	AIR CONDITIONING UNITS	ACU
AIR CONDITIONING UNITS	AIR CONDITIONING SYSTEM	ACU
	WINDOW VENTED AIR CONDITIONER	ACU
	ROOFTOP AIR CONDITIONER	ACU
	FLOOR MOUNTED AIR CONDITIONER	ACU
	SEE ALSO REFRIGERATION UNITS	-
AIR DRYERS	AIR DRYER	AD
	SEE ALSO ION EXCHANGER, PACKED COLUMN, DRYERS	-
AIR FAN	AIR COOLER	HE
AIR FIN	AIR COOLER	HE
ALKYLATION REACTOR	SEE HORIZONTAL TANKS, AGITATORS, REACTORS	-
ALKYLATORS	SEE REACTORS	-
ATMOSPHERIC FILTRATION	DUST COLLECTOR	DC
	FILTER	F
AUTOCLAVES	AUTOCLAVE	APT
AZEOTROPIC DISTILLATION SYSTEM	SEE DISTILLATION SYSTEM	-
	B	
BAFFLE-TOWER EXTRACTORS	SEE PACKED COLUMNS, TRAY TOWERS	-
BAG FILTERS	SEE DUST COLLECTORS	-
BAGGER	PACKAGING MACHINE	PKG
BAGHOUSE	CLOTH BAY DUST COLLECTOR	DC
	AUTOMATIC CLOTH DUST COLLECTOR	DC
BEATERS	KNEAKER	K
	MIXER	MX
BELT FEEDERS	APRON CONVEYOR	CO
BIN	STORAGE TANK	VT
	LIGHT GAGE TANK	VT
	CONE ROOF TANK	VT
	CONICAL TANK	VT
	FLOATING ROOF TANK	VT
	LIFTER ROOF TANK	VT
	SEE ALSO TANK, VESSEL, RECEIVER	-
BIO-OXIDATION UNITS	SEE UNDER SPECIFIC ITEM	-
BIOLOGICAL WASTE UNITS	SEE UNDER SPECIFIC ITEM	-
BLENDERS	BLENDER	BL
	ROTARY DOUBLE-CONE BLENDER	BL
	RIBBON BLENDER	BL
	SEE ALSO KNEADERS, MIXERS	-
BLOWERS	FAN	FN
BOILERS	BOILER	WTS
BRIDGE BREAKER	FEEDER	FE
BUBBLE CAPS	BUBBLE CAP TRAY TOWER	TW
BUCKETS	SEE ELEVATORS, CONVEYORS	-

C

CALANDRIAS	SHELL + TUBE CALANDRIA	HE
	SEE ALSO HEAT EXCHANGER, EVAPORATOR	-
CALCINERS	SEE ROTARY DRYERS	-
CANNED-MOTOR PUMPS	GEAR PUMPS	GP
CATALYST	PACKING	TW
CATALYST BED REACTORS	PACKED COLUMN	TW
	ALSO SEE TOWERS, REACTORS, VESSELS	-
CENTRIFUGAL PUMPS	MODERATE SERVICE CLOSED IMPELLER	CP
	HEAVY DUTY SERVICE CLOSED IMPELLER	CP
	GENERAL SERVICE CLOSED IMPELLER	CP
	GENERAL SERVICE OPEN IMPELLER	CP
	AMERICAN VOLUNTARY STANDARD CLOSED IMPELLER	CP
	CLOSED IMPELLER	CP
	CENTRIFUGAL PUMP TURBINE DRIVER	CP
	CENTRIFUGAL PUMP MOTOR DRIVER	CP
	SEE ALSO PUMPS, FANS, COMPRESSORS	-
CENTRIFUGAL CLASSIFIERS	CENTRIFUGAL PRECIPITATOR	DC
	CYCLONE DUST COLLECTOR	DC
	MULTI-CYCLONE DUST COLLECTOR	DC
CENTRIFUGAL EXTRACTOR	CONTINUOUS CENTRIFUGAL EXTRACTOR	EX
	ALSO SEE CENTRIFUGES	-
CENTRIFUGAL FANS	FANS	FN
CENTRIFUGAL FILTERS	FILTERS	F
	CENTRIFUGES	CT
	DUST COLLECTORS	DC
CENTRIFUGAL SEPARATOR	CYCLONE DUST COLLECTOR	DC
	CENTRIFUGE	CT
CENTRIFUGAL SETTLERS	CENTRIFUGES	CT
	DUST COLLECTORS	DC
CENTRIFUGAL WET COLLECTOR	CENTRIFUGAL PRECIPITATOR DUST COLLECTOR	DC
CENTRIFUGALS	SEE CENTRIFUGES, FLOATATION MACHINES, CRYSTALLIZERS, COMPRESSORS	-
CENTRIFUGES	A.T.M. SUSPENDED CENTRIFUGE	CT
	SOLID BOWL CENTRIFUGE	CT
	RECIPROCATING CONVEYOR CENTRIFUGE	CT
	SCROLL CONVEYOR CENTRIFUGE	CT
	HIGH SPEED DISK CENTRIFUGE	CT
	HIGH SPEED TUBULAR CENTRIFUGE	CT
	BATCH AUTOMATIC CENTRIFUGE	CT
	SUPER D HYDRATOR CENTRIFUGE	CT
	BATCH TOP SUSPENDED CENTRIFUGE	CT
	BATCH BOTTOM SUSPENDED CENTRIFUGE	CT
	BATCH BOTTOM DRIVEN, TOP UNLOADING CENTRIFUGE	CT
	BATCH BOTTOM DRIVEN, BOTTOM UNLOADING CENTRIFUGE	CT
	SEE ALSO FLOATATION MACHINES	-
CHAIN CONVEYORS	CONVEYORS	CO
CHEMICAL REACTORS	REACTORS	-
CHILLERS	HEAT EXCHANGER	HE
	REFRIGERATION UNITS	RU
	CONDENSERS	C
	FREEZERS	FR
CHIMNEYS	STACK	STK
CHUTES	CONVEYOR	CO
CLARIFIERS	FILTER	F
	THICKENER	T
	FILTERS	F
	CENTRIFUGES	CT
	DUST COLLECTORS	DC
CLASSIFIERS	SEE SCREENS	
CLARIFIER	THICKENER	T
COILS	PLATE COIL HEAT EXCHANGER	HE
	SPIRAL COIL HEAT EXCHANGER	HE
	SEE ALSO HEAT EXCHANGERS	-
COLLECTION SYSTEM	DUST COLLECTOR	DC
COLLECTORS	SEE DUST COLLECTORS, FILTERS	-
COLUMNS	PACKED COLUMN	TW
	TRAY TOWERS	TW
	WASHERS	DC
	ALSO SEE VESSELS	-
COMBUSTION EQUIPMENT	FURNACES	FU
	HEATING UNITS	HU
	STACKS	STK
	SEE ALSO DRYERS, ROTARY DRYERS, FIRED PROCESS EQUIPMENT	-
COMBUSTION UNITS		
COMMINUTOR	CUTTER	CU
	MILL	M
COMPACTORS	SEE PRESSES	-
COMPOUNDERS	SEE PRESSES	-
COMPRESSED AIR SYSTEMS	SEE COMPRESSORS	
COMPRESSORS	SEE AIR COMPRESSORS, GAS COMPRESSORS, FANS, TURBINES	-
COMPRESSORS, AIR	SINGLE RECIPROACATING - ONE STAGE	AC
	SINGLE RECIPROCATING - TWO STAGE	AC
	SINGLE RECIPROCATING - THREE STAGE	AC
	DUPLEX RECIPROCATING - TWO STAGE	AC
	CENTRIFUGAL TURBINE DRIVE	AC
	CENTRIFUGAL MOTOR DRIVE	AC
	RECIPROCATING GAS ENGINE DRIVE	AC
	RECIPROCATING MOTOR DRIVE	AC
	SEE ALSO GAS COMPRESSORS, FANS	-

COMPRESSORS, GAS	RECIPROCATING GAS ENGINE DRIVE	GC
	RECIPROCATING MOTOR DRIVE	GC
	CENTRIFUGAL TURBINE DRIVE COMPRESSOR	GC
	CENTRIFUGAL MOTOR DRIVE COMPRESSOR	GC
	RECIPROCATING COMPRESSOR	GC
	SEE ALSO AIR COMPRESSORS, FANS	-
CONCENTRATORS	THICKENER	T
	REACTOR	APT
CONDITIONERS	SEE AIR CONDITIONING UNITS, WATER TREATMENT SYSTEMS	-
CONDITIONING TANK	SEE REACTOR, VESSEL, BIN, TANK	-
CONDENSERS	BAROMETRIC CONDENSER	C
	SEE ALSO HEAT EXCHANGERS	-
CONICAL HOPPER	CONE ROOF VERTICAL TANK	VT
	LIGHT GAGE VERTICAL TANK	VT
	CONICAL TANK	VT
CONTACTOR	PACKED COLUMN	TW
	ION EXCHANGER	IE
	EXTRACTOR	EX
CONVERTERS	SEE REACTORS, VESSELS	-
CONVEYOR BELTS	CONVEYOR	CO
CONVEYORS	CENTRIFUGAL BUCKET ELEVATOR	CO
	CONTINUOUS BUCKET ELEVATOR	CO
	PNEUMATIC CONVEYING SYSTEM	CO
	ROLLER CONVEYOR	CO
	SCREW CONVEYOR	CO
	VIBRATING CONVEYOR	CO
	SPACED BUCKET ELEVATOR	CO
	APRON CONVEYOR	CO
	OPEN BELT CONVEYOR	CO
	ENCLOSED BELT CONVEYOR	CO
	SEE ALSO ELEVATORS	-
COOKERS	SEE DRYERS, TRAY DRYING SYSTEMS, DRUM DRYERS, ROTARY DRYERS	-
COOLERS	SEE HEAT EXCHANGERS	-
COOLING TOWERS	COOLING TOWER	TW
	COOLING TOWER SYSTEMS	WTS
COOLING WATER SYSTEM	COOLING TOWER	TW
	COOLING TOWER SYSTEM	WTS
	PUMP	P
	PUMPING STATION	WTS
CRUSHERS	CONE CRUSHER	CR
	GYRATORY CRUSHER	CR
	JAW CRUSHER	CR
	ROLL CRUSHER	CR
	ROTARY CRUSHER	CR
	PULVERIZER	CR
	SAWTOOTH CRUSHER	CR
	SEE ALSO MILLS, CUTTERS	-
CRACKERS	FLUIDIZED BED REACTOR	P
	SEE ALSO REACTORS, VESSELS, TOWERS	-
CRACKING FURNACES	SEE FURNACES, CRACKERS, HEATING UNITS	-
CRYOGENIC UNITS	SEE UNDER SPECIFIC ITEM	-
CRYSTALLIZERS	MECHANICAL CRYSTALLIZER	CRY
	OSLO GROWTH TYPE CRYSTALLIZER	CRY
	BATCH VACUUM CRYSTALLIZER	CRY
	FORCED CIRCULATION	CRY
CUTTER	ROTARY KNIFE CUTTER	CU
	SEE ALSO MILLS	-
CRUSHING ROLLS	CRUSHER	CR
	ROLL MILL	M
CYCLONE SCRUBBER	CYCLONE	DC
	MULTI CYCLONE	DC
CYCLONE VESSEL	SEE CYCLONES	-
CYCLONES	CYCLONE DUST COLLECTOR	DC
	MULTI-CYCLONE DUST COLLECTOR	DC
CYLINDERS	SEE COLUMNS, VESSELS	

D

DEAERATORS	SEE MIXERS	-
DEBUTANIZERS	SEE DISTILLATION SYSTEMS	-
DECANTER	SUPER D CENTRIFUGE	CT
	SEE ALSO SEPARATOR	-
DECOLORIZERS	SEE ABSORBERS, ACTIVATED CARBON	
DECOMPOSERS	SEE AGITATED VESSELS	-
DEDUSTERS	SEE DUST COLLECTORS	-
DEFIBERIZERS	SEE CRUSHERS/MILLS	-
DEFLOCCULATORS	SEE CRUSHERS/MILLS	-
DEFOAMERS	SEE MIXERS	-
DEGASIFIERS	SEE DEAERATORS/MIXERS	-
DEGUMMERS	SEE CENTRIFUGES, EVAPORATORS, WIPED FILM EVAPORATORS	-
DEHUMIDIFIERS	DRYERS	D
	AIR CONDITIONING UNIT	ACU
	AIR DRYERS	AD
DEHYDRATORS	SEE DISTILLATION SYSTEMS, DRYERS, ROTARY DRYERS, TRAY DRYING SYSTEMS, EVAPORATORS, WIPED FILM EVAPORATORS, DRUM DRYERS, FLAKERS	
DEIONIZERS	SEE ION-EXCHANGERS, SOFTENERS	-
DEISOBUTINIZERS	SEE DISTILLATION SYSTEMS	-
DEISOPENTANIZERS	SEE DISTILLATION SYSTEMS	-
DELUMPERS	SEE CRUSHERS, MILLS, MIXERS	-

DEMINERALIZER	WATER TREATMENT SYSTEM	WTS
	ION EXCHANGER	IE
	PACKED COLUMN	TW
	PACKING	TW
DENSIFIERS	SEE MIXERS	-
DEODORIZERS	SEE REACTORS, DISTILLATION SYSTEMS, DRYERS	-
DEPROPANIZERS	SEE DISTILLATION SYSTEMS	-
DESICCATORS	SEE ION EXCHANGERS, PACKED COLUMNS, PACKINGS	-
DESILICIZERS	SEE ION-EXCHANGERS	-
DESICCANTS	SEE PACKINGS	-
DESICCATORS	SEE DRYERS, PACKED COLUMNS, PACKINGS	-
DESILTERS	VIBRATING SCREEN	VS
DESLUDGERS	SEE CENTRIFUGES, FILTERS, THICKENERS	-
DESMOGGERS	SEE DUST COLLECTORS, FILTERS	-
DESOLVENTIZERS	SEE DRYERS, DRUM DRYERS, TRAY DRYING SYSTEMS, ROTARY DRYERS, EVAPORATORS, DISTILLATION SYSTEMS	-
DESORBERS	SEE COLUMNS, TOWERS, VESSELS, REACTORS	-
DESTRUCTORS	SEE INCINERATORS	-
DESULFURIZATION REACTOR	PACKED COLUMNS	TW
	SEE ALSO REACTORS, TOWERS, VESSELS	-
DEWATERERS	SEE CENTRIFUGES, FILTERS, DRYERS, ROTARY DRYERS, TURBO DRYING SYSTEMS	-
DEWATERING SYSTEM	CONVEYOR	CO
DEWATERING SYSTEM	VIBRATING SCREEN	VS
	ROTARY VACUUM FILTER	F
	CENTRIFUGAL PUMP	CP
	PUMP	P
	DUST COLLECTOR	DC
	AIR DRYER	AD
	DRYING SYSTEM	-
	INCINERATOR	I
	RECEIVER	-
	VACUUM PUMP	VP
	FILTER	F
	HOPPER	-
DIFFUSERS	SEE MIXERS	-
DIGESTERS	SEE REACTORS, VESSELS	-
DISPERSERS	SEE MIXERS, BLENDERS, AGITATORS	-
DISPOSAL UNITS	SEE UNDER SPECIFIC ITEM	-
DISSOLVERS	SEE MIXERS	
DISTILLATION EQUIPMENT	SEE UNDER SPECIFIC ITEM	-
DISTILLATION UNITS	SEE DISTILLATION SYSTEMS	-
DISTILLATION SYSTEM	TRAY TOWER	TW
	PACKED COLUMN	TW
	HEAT EXCHANGER	HE
	REBOILER	RB
	CONDENSER	C
	PUMP	P
	CENTRIFUGAL PUMP	CP
	VACUUM PUMP	VP
	STILL	WTS
	SEE ALSO RECEIVER	-
DISTILLED WATER SYSTEM	STILL	WTS
	SEE ALSO DISTILLATION SYSTEM	-
DRUM	SEE BIN, RECEIVER, DRUM, VESSEL	-
DRAINERS	SEE CENTRIFUGALS	-
DRIVES	SEE TURBINES	-
DRYING SYSTEM	DRYER	D
	ROTARY DRYER	RD
	TRAY DRYING SYSTEM	TDS
	DRUM DRYER	DD
DRY CHEMICAL FEEDER	FEEDER	F
	CONVEYOR	CO
DRYERS	ATMOSPHERIC TRAY DRYER	D
	VACUUM TRAY DRYER	D
	PAN DRYER	D
	SPRAY DRYER	D
	FLUID BED DRYER	D
	ALSO SEE ROTARY DRYERS, DRUM DRYERS, TRAY DRYING SYSTEMS, FLAKERS	-
DUST COLLECTORS	CLOTH BAY DUST COLLECTOR	DC
	CYCLONE COLLECTOR	DC
	MULTIPLE CYCLONE COLLECTOR	DC
	WASHERS	DC
	AUTOMATIC CLOTH FILTER DUST COLLECTOR	DC
	LOW VOLTAGE ELECTRICAL PRECIPITATOR	DC
	HIGH VOLTAGE ELECTRICAL PRECIPITATOR	DC
	CENTRIFUGAL PRECIPITATOR	DC
	SEE ALSO FILTERS, SEPARATORS	-
DRUM DRYERS	SINGLE ATMOSPHERIC DRUM DRYER	DD
	DOUBLE ATMOSPHERIC DRUM DRYER	DD
	SINGLE ATMOSPHERIC DRUM DRYER	DD
	SEE ALSO DRYERS, FLAKERS, ROTARY DRYERS	-
DUST COLLECTION SYSTEM	DUST COLLECTOR	DC
	FAN	FN

E

ECONOMIZER	HEAT EXCHANGER	HE
	EVAPORATOR	E

	CONDENSER	C
	REBOILER	RB
	BOILER	-
EDUCATORS	EJECTOR	FJ
	STEAM JET REFRIGERATION UNIT	RU
ELECTRICAL GENERATORS	TURBO GENERATOR	EG
	UNIT STEAM AND BOILER	EG
	PORTABLE GENERATOR SET	EG
	SEE ALSO TURBINES	-
EJECTORS	SINGLE STAGE NON-CONDENSING EJECTOR	FJ
	TWO STAGE - BAROMETRIC TYPE OF INTER-	EJ
	CONDENSER	FJ
	FOUR STAGE - BAROMETRIC	EJ
	FIVE STAGE - BAROMETRIC	EJ
	SEE ALSO REFRIGERATION UNITS, VACUUM PUMPS	-
ELECTROSTATIC PRECIPITATOR	DUST COLLECTOR	DC
ELEVATORS	PASSENGER ELEVATOR	EL
	FREIGHT ELEVATOR	FL
	SEE ALSO CONVEYORS	-
EMULSIFIERS	SEE MIXERS	
	SEE ALSO SEPARATORS	-
ENGINES	SEE TURBINES, ELECTRICAL GENERATOR UNITS	-
EVACUATORS	SEE EJECTORS	-
EVAPORATORS	AGITATED FALLING FILM EVAPORATOR	E
	FORCED CIRCULATION EVAPORATOR	E
	LONG-TUBE RISING FILM EVAPORATOR	E
	STANDARD HORIZONTAL TUBE EVAPORATOR	E
	STANDARD VERTICAL TUBE EVAPORATOR	F
	JACKETED VESSEL TYPE EVAPORATOR	E
	LONG TUBE VERTICAL EVAPORATOR	E
	SEE ALSO WIPED FILM EVAPORATORS, HEAT EXCHANGERS, FURNACES, HEATING UNITS	-
EXCHANGE RESIN	PACKING	TW
	PACKED COLUMN	TW
	ION EXCHANGER	IE
EXCHANGER	HEAT EXCHANGER	HE
	REBOILER	RB
	EVAPORATOR	E
	CONDENSER	-
EXTRACTORS	CONTINUOUS CENTRIFUGAL EXTRACTOR	EX
	SEE ALSO CENTRIFUGES	-
EXHAUSTERS	SEE BLOWERS, FANS, VACUUM PUMPS, COMPRESSORS, EJECTORS, GEAR PUMPS, CENTRIFUGAL PUMPS	-
EXTRACTORS	EXTRACTOR	EX
	AGITATED PRESSURE TANKS	APT
	CENTRIFUGE	CT
EXTRACT FURNACES	SEE FURNACES, HEATING UNITS	-
EXTRACTION COLUMNS	SEE AGITATED VESSELS, VESSELS, REACTORS	-
EXTRUDERS	MIXER	MX

F

FANS	CENTRIFUGAL TURBO BLOWER	FN
	CENTRIFUGAL COMPRESSOR	FN
	PROPELLER FAN	FN
	ROTARY BLOWER	FN
	VANEAXIAL FAN	FN
	CENTRIFUGAL FAN	FN
	SEE ALSO GAS COMPRESSORS, AIR COMPRESSORS, PUMPS	-
FEED HEATER	SEE HEATERS	-
FEED PUMP	SEE PUMP	-
FEED TANK	SEE TANK, VESSEL	-
FEEDERS	BELT FEEDER	FF
	CHAMBER FEEDER	FE
	LOSS IN WEIGHT FEEDER	FF
	ROTARY FEEDER	FF
	SEE ALSO CONVEYORS	-
FIBERIZERS	SEE MILLS	-
FIELD ERECTED VESSELS	SPHERES	VT
	SPHEROIDS	VT
	CONE ROOF TANKS	VT
	CONICAL TANKS	VT
	FLOATING ROOF TANKS	VT
	LIFTER ROOF TANKS	VT
	GAS HOLDERS	VT
	OPEN TOP TANKS	VT
	AGITATED OPEN TANKS	AOT
	THICKENERS	T
	TRAY TOWERS	TW
	PACKED COLUMNS	TW
	API TANKS	VT
	STORAGE TANKS	VT
	LIGHT GAGE TANKS	VT
FILTER BAGS	SEE FILTERS, DUST COLLECTORS	-
FILTER CLOTHS	SEE FILTERS, DUST COLLECTORS	-
FILTER LEAVES	SEE FILTERS	-
FILTER PRESSES	PLATE + FRAME FILTER PRESS	F
	HYDRAULIC PRESS	PR

FILTER SCREENS	VIBRATING SCREENS	VS
FILTER UNIT	FILTER	F
	SEE ALSO SEPARATORS	-
FILTERS	SPARKLER FILTER	F
	ROTARY DRUM FILTER	F
	ROTARY DISK FILTER	F
	PLATE AND FRAME FILTER	F
	PRESSURE LEAF-DRY FILTER	F
	PRESSURE LEAF-WET FILTER	F
	SEWAGE FILTER SYSTEM	F
	SEE ALSO DUST COLLECTORS, SEPARATORS	-
FILTRATE RECEIVERS	SEE RECEIVERS	-
FILTRATE TANK	SEE TANK, VESSEL, RECEIVER	-
FILTRATION	FILTER	F
	DUST COLLECTOR	DC
FINISHER	WIPED FILM EVAPORATOR	WFE
	EVAPORATOR	F
	DRUM DRYER	DD
	ALSO SEE TUBULAR REACTOR, REACTOR	-
FINISHING	SEE MILLS	-
FIRED PROCESS EQUIPMENT	FURNACES	FU
	HEATING UNITS	HU
	BOILERS	WTS
	STACKS	STK
	DRYERS	D
	ROTARY DRYERS	RD
	STILL	WTS
FIRED ROTARY KILN	ROTARY DRYER	RD
FLAKERS	DRUM FLAKER	FL
	DRUM DRYER	DD
	SEE ALSO DRUM DRYERS	-
FLOATATION MACHINES	FLOATATION MACHINE	FM
	SEE ALSO CENTRIFUGES	-
FLASH DRUM	SEE DRUMS, VESSELS, REACTORS, TANKS	-
FLASH TOWERS	SEE TOWERS	-
FLOTATION UNITS	FLOATATION MACHINE	FM
FLUE GAS SCRUBBING SYSTEM	SCRUBBER	-
	DUST COLLECTOR	DC
	FILTER	F
	FAN	FN
	PACKED COLUMN	TW
	PACKING	TW
FLUIDIZED BED REACTOR	FLUIDIZED BED REACTOR	R
	SPHERES	VT
	SPHEROIDS	VT
	ION EXCHANGERS	IE
	WASHERS	DC
FLUIDIZING CONVEYOR SYSTEMS	SEE CONVEYORS	-
FLOTATION UNITS	SEE FLOATATON MACHINE, THICKENER, REACTORS	-
FRACTIONATORS	SEE DISTILLATION SYSTEMS	-
FRAME FILTER	PLATE AND FRAME FILTER PRESS	F
FREEZERS	FREEZER	FR
	SEE ALSO REFRIGERATION UNITS, AIR CONDITIONING UNITS	-
FUME COLLECTORS	DUST COLLECTOR	DC
FUME EXHAUST SYSTEMS	SEE PUMPS, FANS	-
FUMIGATORS	SEE VESSELS	-
FURNACES	PROCESS HEATER FURNACE	FU
	VERTICAL FURNACE	FU
	BOX FURNACE	FU
	PYROLYSIS FURNACE	FU
	REFORMER FURNACE	FU
	SEE ALSO HEATING UNITS	-

G

GAS CONVEYING SYSTEM	PNEUMATIC CONVEYING SYSTEM	CO
	GAS COMPRESSOR	GC
	AIR COMPRESSOR	AC
	FAN	FN
	SEE ALSO RECEIVER, VESSEL, BIN	-
GAS ABSORBER	PACKED COLUMN	TW
	ION EXCHANGER	IF
	PACKING	TW
GASHOLDERS	GAS HOLDER	VT
	SEE ALSO VESSELS	-
GAS SCRUBBER	SEE SCRUBBER	-
GEAR PUMPS	GEAR PUMP	GP
	CANNED ROTOR GEAR PUMP	GP
	MECHANICAL SEAL TYPE GEAR PUMP	GP
	SEE ALSO PUMPS, VACUUM PUMPS	-
GAS WASH COLUMN	SEE COLUMNS, TOWERS	-
GENERATORS	TURBINES	TUR
	ELECTRICAL GENERATOR UNITS	EG
GLASS-LINED STEEL EQUIPMENT	SEE APPROPRIATE EQUIPMENT ITEM	-
GRANULATORS	SEE CRUSHERS, MILLS	-
GRINDERS	SEE CRUSHERS, MILLS	-

H

HALOGENATORS	SEE MIXERS	-
HAMMERMILLS	SEE CRUSHERS, MILLS	-
HEAT EXCHANGERS	SHELL AND TUBE HEAT EXCHANGER	HE
	SHELL AND TUBE CALANDRIA	HE
	GLASS COIL IN GLASS SHELL EXCHANGER	HE
	FLOATING HEAD TYPE HEAT EXCHANGER	HE
	FIXED TUBE SHEET TYPE HEAT EXCHANGER	HE
	U-TUBE TYPE HEAT EXCHANGER	HE
	TANK HEATER - STEAM COIL	HE
	TANK HEATER - IMMERSION	HE
	JACKETED PIPE EXCHANGER	HE
	TANK SUCTION HEATER	HE
	TWIN SCREW	HE
	THERMASCREW (RIETZ) SINGLE SCREW	HE
	TWIN SCREW AGITATED AND JACKETED	HE
	WASTE HEAT BOILER	HE
	CASCADE COOLER	HE
	PLATE COIL HEADER TYPE SERPENTINE TYPE	HE
	DRIP COOLER	HE
	FIN TUBE EXCHANGER	HE
	AIR COOLER	HE
	U-TUBE HEAT EXCHANGER	HE
	SPIRAL TUBE HEAT EXCHANGER	HE
	SPIRAL PLATE HEAT EXCHANGER	HE
	SEE ALSO HEATING UNITS, EVAPORATORS, FURNACES, REFRIGERATION UNITS, CONDENSERS, FREEZERS, AIR CONDITIONING UNITS	-
HEAT RECOVERY UNITS	SEE FURNACES, HEATING UNITS, BOILERS, HEAT EXCHANGERS	-
HEAT TRANSFER SYSTEM	HEAT EXCHANGER	HE
	CONDENSER	C
	REBOILER	RB
	EVAPORATOR	E
	WIPED FILM EVAPORATOR	WFE
	COOLING TOWER SYSTEM	WTS
	COOLING TOWER	TW
	HEATING UNIT	HU
	FREEZER	FR
	FURNACE	FU
	AIR COOLER	HE
	REFRIGERATION UNIT	RU
	ALSO SEE DRYER, REFRIGERATION SYSTEM	-
HEATERS	SEE FURNACES, HEATING UNITS, HEAT EXCHANGERS	-
HEATING UNITS	DOWTHERM	HU
	PROCESS HEATER TYPE HEATING UNIT	HU
	SEE ALSO FURNACES	-
HIGH-EFFICIENCY CENTRIFUGAL COLLECTOR	MULTI CYCLONE DUST COLLECTOR	DC
HIGH EFFICIENCY CYCLONE	CYCLONE DUST COLLECTOR	DC
	MULTI CYCLONE DUST COLLECTOR	DC
HIGH VELOCITY SCRUBBER	WASHER	DC
	SEE ALSO SCRUBBER	-
HOISTS	5-SPEED ELECTRIC HOIST WITH MOTOR DRIVE TROLLEY	HO
	HAND HOIST, PLAIN TROLLEY	HO
	HAND HOIST, GEARED TROLLEY	HO
	HAND HOIST, NO TROLLEY	
	SINGLE-SPEED ELECTRIC HOIST, NO TROLLEY	HO
	5-SPEED ELECTRIC HOIST, NO TROLLEY	HO
	SEE ALSO CRANES	-
HOLDING TANK	SEE VESSEL, TANK, BIN, DRUM	-
HOMOGENIZERS	SEE MIXERS	-
HOPPER	SEE BIN, TANK, VESSEL, RECEIVER	-
HORIZONTAL PLATE FILTER	SPARKLER FILTER	F
HORIZONTAL TANKS	VACUUM RECEIVER	HT
	JACKETED VACUUM RECIEVER	HT
	CYLINDRICAL VESSEL	HT
	SPHERE	VT
	STORAGE TANK	VT
	SPHEROID	VT
	SEE ALSO VESSELS, TANKS	-
HYDRAULIC CONVEYOR SYSTEMS	PNEUMATIC CONVEYOR SYSTEM	CO
HYDRO-EXTRACTORS	SEE CENTRIFUGALS	-
HYDROGENATION REACTOR	PACKED COLUMN	TW

I

IMPACTORS	SEE CRUSHERS, MILLS	-
IMPELLERS	SEE AGITATORS, MIXERS	-
IMPREGNATORS	SEE VESSELS	-
INCINERATION SYSTEM	INCINERATOR	I
	STACK	STK

	FAN	FN
	CONVEYOR	CO
	TANK	-
INCINERATORS	INCINERATOR	T
INTENSIFIERS	MIXERS	MX
	BLENDERS	BL
	KNEADERS	K
INTERCOOLERS	SEE HEAT EXCHANGERS, AIR DRYERS	-
INERTIAL WET COLLECTOR	CENTRIFUGAL PRECIPITATOR DUST COLLECTOR	DC
ION EXCHANGERS	ANION TYPE ION EXCHANGER	
	HYDROGEN CYCLE CATION TYPE ION EXCHANGER	IE
	SODIUM CYCLE CATION TYPE ION EXCHANGER	IE
	SEE ALSO PACKED COLUMNS, WATER TREATMENT SYSTEMS	-
ION-EXCHANGE RESINS	PACKING	TW
	SEE ALSO ION EXCHANGERS, PACKED COLUMS	-
ION RETARDATION UNITS	SEE ION EXCHANGERS, REACTORS	-
ISOMERIZATION REACTORS	SEE DISTILLATION SYSTEMS	-
ISOSTRIPPER	SEE DISTILLATION SYSTEMS	-

J

JACKETED REACTOR	REACTOR	-
JET VACUUM EQUIPMENT	EJECTORS	EJ
	STEAM JET REFRIGERATION UNIT	RU

K

KETTLES	SEE REACTORS, REBOILERS	-
	CRYSTALLIZERS	-
KILNS	SEE ROTARY DRYERS	-
KNEADERS	STATIONARY, UPRIGHT DOUBLE-ARM KNEADER	K
	TILTING, DOUBLE-ARM KNEADER	K
	VACUUM, TILTING-TYPE DOUBLE-ARM KNEADER	K
	SEE ALSO BLENDERS, MIXERS	-
KNOCK-OUT DRUM	HORIZONTAL TANKS	HT
	VERTICAL TANKS	VT
	ALSO SEE VESSELS, TANKS	-
KYMER DIGESTER	SEE REACTOR, VESSEL	-

L

LEACHERS	SEE VESSELS, REACTORS	-
LOADER	FEEDER	FE
	CONVEYOR	CO
	HOIST	HO
	ELEVATOR	EL

M

MAIN COLUMN	SEE TOWERS	-
MAIN FRACTIONATORS	SEE DISTILLATION SYSTEMS	-
MAKE-UP AIR UNITS	SEE BLOWERS, FANS, COMPRESSORS	-
MAKEUP COMPRESSOR	COMPRESSORS	-
MANCOOLERS	SEE FANS, AIR CONDITIONING UNITS	-
MASTICATORS	SEE MIXERS, AGITATORS, BLENDERS	-
MECHANICAL COLLECTOR	DUST COLLECTOR	DC
METERING PUMP	PUMP	P
	GEAR PUMP	GP
METHANATORS	SEE TOWERS, COLUMNS, VESSELS, REACTORS	-
MICRONIZERS	SEE MILLS, CRUSHERS	-
MIX-COOKES	SEE DRUM DRYER, DRYER, MIXER, TURBO DRYING SYSTEM	-
MILLS	ATTRITION MILL	M
	SWING HAMMER MILL	M
	MIKRO-PULVERIZER	M
	ROLLER MILL	M
	BALL MILL	M
	HAMMER MILL	M
	SEE ALSO CRUSHERS	-
MIXERS	SIGMA MIXER	
	FIXED PROPELLER MIXER	
	PORTABLE PROPELLER MIXER	
	EXTRUDER-STEEL CYLINDRICAL VARIABLE DRIVE	MX
	EXTRUDER-MULLER	MX
	SPIRAL RIBBON MIXER	MX
	TWO-ROLL MIXER	MX
	PAN MIXER	MX
	AGITATED OPEN TANK	AOT
	AGITATED PRESSURE TANK	APT
	ROTARY BLENDER	BL
	RIBBON BLENDER	BL
	BLENDER	BL
	SEE ALSO BLENDERS, KNEADERS, AGITATORS	-
MULTI-STAGE PUMP	CENTRIFUGAL PUMP	CP
	PUMP	P
MULLERS	SEE MIXERS	-

N

NEUTRALIZERS	SEE MIXERS, VESSELS, REACTORS REINFORCED CONCRETE ITEM	-
NITRATORS	SEE VESSELS, REACTORS	-
NODULIZERS	SEE KILNS	-

O

OXIDIZER	SEE REACTORS, VESSELS, COLUMNS, TOWERS	-

P

PACKAGING EQUIPMENT	VOLUME BAGGER	PKG
	WEIGHT BAGGER	PKG
PACKAGING MACHINES	BAGGING MACHINE PACKED BY WEIGHT	PKG
	BAGGING MACHINE PACKED BY WEIGHT	PKG
PACKED COLUMN	PACKED COLUMN	TW
PACKERS	SEE PACKAGING EQUIPMENT	-
PACKING	SEE UNDER SPECIFIC ITEM	TW
	SEE ALSO PACKED COLUMNS, ION EXCHANGERS	-
PANS	PAN MIXER	MX
	PAN DRYER	D
PANEL FILTER	CLOTH BAY DUST COLLECTOR	DC
PASTEURIZERS	AUTOCLAVES	APT
	SEE ALSO VESSELS, REACTORS	-
PELLETIZERS	ROTARY KNIFE CUTTER	CU
PERCOLATORS	SEE VESSELS, REACTORS	-
PILOT-SCALE EQUIPMEN	SEE UNDER SPECIFIC ITEM	-
PIPELINE REACTOR	JACKETED PIPE HEAT EXCHANGER	HE
	ALSO SEE TUBULAR REACTOR, HEAT EXCHANGER, REACTOR	-
PLATE COILS	PLATE COIL HEAT EXCHANGER	HE
PLATE TOWER	TRAY TOWER	TW
PNEUMATIC CONVEYOR SYSTEMS	PNEUMATIC CONVEYING SYSTEM	CO
	SEE ALSO FANS, COMPRESSORS, YARD PIPE	-
POLYMERIZER	AGITATED PRESSURE TANK	APT
	WIPED FILM EVAPORATOR	WFE
	ALSO SEE REACTOR, TUBULAR REACTOR	-
POTS	SEE VESSELS, REACTORS, TANKS, DRUMS	-
POWER RECOVERY TURBINES	TURBINE	TUR
	ELECTRICAL GENERATOR	EG
PREBREAKERS	SEE CRUSHERS, MILLS	-
PRECIPITATORS	SEE TANKS, THICKENERS	-
PREHEAT FURNACE	SEE FURNACES, HEATING UNITS	-
PREHEATERS	SEE HEATERS	-
PRESSES	HYDRAULIC PRESS	PR
PRESCRUBBER	SEE SCRUBBER	-
PRESSURE FILTER	FILTER	F
	ALSO SEE SEPARATOR	-
PRIMARY CLARIFIER	THICKENER	T
PROCESS COOLERS	SEE HEAT EXCHANGERS, COOLING TOWER SYSTEMS	-
PROCESS HEATER	HEAT EXCHANGER	HE
	FURNACE	FU
	HEATING UNIT	HU
PROCESSORS	SEE REACTORS, DRYING SYSTEMS	-
PRODUCT PUMP	SEE PUMP	-
PRODUCT TANK	SEE TANK, VESSEL, RECEIVER	-
PROPANE ACCUMULATORS	SEE ACCUMULATORS	-
PULP DIGESTER	SEE REACTOR, VESSEL	-
PUMPS	RECIPROCATING - SIMPLEX, STEAM DRIVE	P
	RECIPROCATING - DUPLEX STEAM DRIVE	P
	TRIPLEX OR PLUNGER MOTOR DRIVE	P
	DIAPHRAGM TFE TYPE SLURRY TYPE	P
	ROTARY PUMP	P
	GEAR PUMP	P
	SEE ALSO GEAR PUMPS, CENTRIFUGAL PUMPS, VACUUM PUMPS, FANS	-
PUMPING STATION	CENTRIFUGAL PUMP	CP
	PUMP	P
	PUMPING STATION	WTS
PUMPING SYSTEMS	PUMPING STATIONS	WTS
	SEE ALSO PUMPS, CENTRIFUGAL PUMPS	-
PURIFIERS	SEE DUST COLLECTORS, FILTERS, CENTRIFUGES, DRYING SYSTEMS, DISTILLATION SYSTEMS	-
PURIFICATION SYSTEM	FILTER	F
	CENTRIFUGE	CT
	DUST COLLECTOR	DC
	ALSO SEE SEPARATOR	-

R

RAFFINATE FURNACES	SEE FURNACES, HEATING UNITS	-
RAILROAD TANK CARS	CHLORINE TYPE TANK CAR	RTC
REACTION VESSEL	SEE REACTOR, VESSEL	-
REACTORS	AGITATED OPEN TANK	AOT
	FLUIDIZED BED SINGLE STAGE REACTOR	R
	FLUIDIZED BED DOUBLE STAGE REACTOR	R
	AGITATED PRESSURE TANK	APT
	MIXER	MX
	ALSO SEE REACTOR, VESSEL	-
REBOILERS	KETTLE TYPE REBOILER	HE
	U-TUBE REBOILER	HE
	SEE ALSO HEAT EXCHANGERS, EVAPORATORS	-
RECEIVER	HORIZONTAL PRESSURE VESSEL	HT
	VERTICAL PRESSURE VESSEL	VT
	ALSO SEE VESSEL, TANK, DRUM	-
RECYCLE CLARIFIER	VIBRATING SCREEN	VS
REFRIGERANT CONDENSER	HEAT EXCHANGER	HE
	REFRIGERATION UNIT	RU
	AIR COOLER	HE
	AIR CONDITIONING UNIT	ACU
REACTION SYSTEMS	SEE REACTORS, DISTILLATION SYSTEMS	-
REACTORS	REACTOR	APT
	AUTOCLAVE	APT
	HORIZONTAL CYLINDRICAL PRESSURE VESSEL	HT
	VERTICAL CYLINDRICAL PRESSURE VESSEL	VT
	TRAY TOWER	TW
	PACKED COLUMN	TW
	JACKETED HORIZONTAL VACUUM VESSEL	HT
	JACKETED VERTICAL VACUUM VESSEL	VT
	AGITATED PRESSURE VESSEL	APT
	AGITATED OPEN TANK	AOT
RECYCLE COMPRESSOR	COMPRESSORS	-
REFORMERS	REFORMER FURNACE	FU
REFRIGERATION MACHINERY	REFRIGERATION UNIT	RU
	AIR CONDITIONING UNIT	ACU
	FREEZER	FR
REFRIGERATION UNITS	MECHANICAL COMPRESSION UNIT	RU
	STEAM JET REFRIGERATION UNIT	RU
	CENTRIFUGAL COMPRESSION UNIT	RU
	SEE ALSO FREEZERS, AIR CONDITIONING UNITS	-
REGENERATORS	SEE HEAT EXCHANGERS, VESSELS, REACTORS, EVAPORATORS, BOILERS	-
REHEATER	SEE HEATER	-
REPULPING VESSELS	SEE AGITATED VESSELS	-
RESIN	PACKING	TW
	ION EXCHANGER	IE
RETORTS	SEE DISTILLATION SYSTEMS, REACTORS	-
REVERSE OSMOSIS SYSTEM	HORIZONTAL PRESSURE VESSEL	HT
	ALSO SEE PUMP, TUBULAR REACTOR, VESSEL	-
RISER CRACKERS	SEE CRACKERS	-
ROASTERS	SEE KILNS, DRYERS, REACTORS	-
ROLLERS	SEE MIXERS	
ROTARY DRYERS	DIRECT ROTARY DRYER	RD
	BATCH ROTARY VACUUM DRYER	RD
	INDIRECT ROTARY DRYER	RD
	SEE ALSO DRUM DRYERS, FLAKERS, TURBO DRYING SYSTEMS, DRYERS	-
ROASTERS	SEE DRYING SYSTEMS	-
ROTARY VACUUM FILTER SYSTEM	ROTARY VACUUM FILTER	F
	VACUUM PUMP	VP
	EJECTOR	EJ
	ALSO SEE RECEIVER, VESSEL	-
ROTATING DRYER	ROTARY DRYER	RD
	DRUM DRYER	DD
	ALSO SEE DRYER	-
ROTARY VACUUM SYSTEM	SEE ROTARY VACUUM FILTER SYSTEM	-

S

SAFETY EQUIPMENT	SEE UNDER SPECIFIC ITEM	-
SAMPLING PUMP	SEE PUMP	-
SCALES	TANK SCALE	S
SCALPERS	SEE VIBRATING SCREENS	-
SCRAPER KETTLES	SEE REACTORS	-
SCREEN CLOTH FILTER	ROTARY VACUUM FILTER	F
	ROTARY DRUM FILTER	F
	ROTARY DISK FILTER	F
	PLATE AND FRAME FILTER PRESS	F
	ALSO SEE ROTARY VACUUM FILTER SYSTEM	-
SCREEN	VIBRATING SCREEN	VS
SCREW DRYERS	SEE SCREW HEATERS	-
SCREW HEATERS	ONE SCREW THERMASCREW	HE

	TWO SCREW THERMASCREW	HE
	SCREW CONVEYOR	CO
SCRUBBERS	WASHERS	DC
	PACKED COLUMN	TW
	SEE ALSO PACKING	TW
	TRAY TOWER	TW
	ALSO SEE VESSEL	-
SCRUBBING TOWER	SEE SCRUBBER	-
SECONDARY CLARIFIER	SEE CLARIFIER	-
SEPARATORS	VIBRATING SCREENS	VS
	FILTERS	F
	DUST COLLECTORS	DC
	THICKENER	T
	EXTRACTOR	EX
	VIBRATING SCREEN	VS
	ALSO SEE DISTILLATION SYSTEM, DRYER	-
SETTLERS	SEE CLARIFIERS, FILTERS, DUST COLLECTORS, TANKS, VESSELS	-
SEPARATION VESSELS	SEE VESSELS	-
SETTLING TANK	THICKENER	T
	ALSO SEE VESSEL	-
SEWAGE PUMP	CENTRIFUGAL PUMP	CP
	ALSO SEE PUMP	-
SEWAGE TREATING EQUIPMENT	SEE UNDER SPECIFIC ITEM	-
SHIFT CONVERTERS	SEE COLUMNS, REACTORS, VESSELS	-
SHREDDERS	SEE CRUSHERS, MILLS, CUTTERS	-
SILOS	SEE VESSELS	-
SILO HOPPER	LIGHT GAGE VERTICAL TANK	VT
	VERTICAL STORAGE VESSEL	VT
SIMPLE CYCLONE	CYCLONE DUST COLLECTOR	DC
SINGLE-STAGE ELECTRICAL PRECIPITATOR	LOW-VOLTAGE ELECTRICAL PRECIPITATOR DUST COLLECTOR	DC
	HIGH-VOLTAGE ELECTRICAL PRECIPITATOR DUST COLLECTOR	DC
SIZE REDUCTION EQUIPMENT	SEE CRUSHERS, MILLS, CUTTERS, KNEADERS	-
SOFTENERS	WATER SOFTENING SYSTEMS	WTS
	ION EXCHANGERS	IE
	PACKING	TW
	COOLING TOWER SYSTEM	WTS
	PACKED COLUMN	TW
	COOLING TOWER	TW
SOLVENT RECOVERY EQUIPMENT	SEE DISTILLATION SYSTEMS, DRYERS, HEAT EXCHANGERS, TRAY DRYING SYSTEMS, DRUM DRYERS, FILTERS	-
SPARE PUMP	PUMP	P
SPHERES	SPHERE	VT
	SPHERIOD	VT
SPRAY CHAMBER	WASHER DUST COLLECTOR	DC
	ALSO SEE SCRUBBER, VESSEL	-
SPRAY CHAMBER WET COLLECTOR	WASHER DUST COLLECTOR	DC
SPARY MIXERS	SEE MIXERS	-
SPRAY TOWER	WASHER DUST COLLECTOR	DC
	SEE ALSO REACTORS, VESSELS	-
	COOLING TOWER SYSTEM	WTS
	COOLING TOWER	TW
	PACKED COLUMN	TW
	ALSO SEE SCRUBBER, VESSEL	-
SPREADERS	SEE CENTRIFUGALS	-
STABILIZERS	SEE DISTILLATION SYSTEMS	-
STACKS	STACK	STK
STAR FEEDER	ROTARY FEEDER	FF
STATIONS	PUMPING STATION	WTS
STEAM HEATING SYSTEM	BOILER	WTS
	EVAPORATOR	F
STEAM PLANT	WATER TREATMENT SYSTEM	WTS
STERILIZERS	AUTOCLAVES	APT
STILLS	STILL	WTS
STIRRED VESSEL	AGITATED OPEN TANK	AOT
	REACTOR	-
	AGITATED PRESSURE TANK	APT
	THICKENER	T
	AGITATOR	AG
STRIPPERS	SEE COLUMNS, TOWERS, DISTILLATION SYSTEMS	-
SUBLIMERS	TURBO TRAY DRYER	TDS
SUCTION DRUM	VACUUM RECEIVER - HORIZONTAL	HT
	VACUUM RECEIVER -VERTICAL	VT
	ALSO SEE VESSELS, REACTORS, DRUMS	-
SULFONATION REACTOR	AGITATED TANK	APT
	ALSO SEE VESSEL, TUBULAR REACTOR	-
SULFONATORS	SEE REACTORS, VESSELS	-
SUMPS	SEE VESSELS	-
SUPERHEATERS	BOILER	WTS
SURGE BIN	SEE BIN	-
SURGE HOPPER	SEE VESSELS	-
SWING REACTOR	SEE REACTORS	-

T

TANK	STORAGE TANK	VT
	HORIZONTAL TANK	HT
	VERTICAL TANK	VT
	ALSO SEE BIN, DRUM, VESSEL, RECEIVER	-
TEXTURIZERS	SEE MIXERS	-
THERMO-COMPRESSORS	SEE COMPRESSORS	-
THICKENERS	CONTINUOUS SINGLE COMPARTMENT THICKENER	T
	DOUBLE COMPARTMENT THICKENER	T
TOPING SECTION	SEE DISTILLATION SYSTEM	-
TRAY DRYING SYSTEMS	TURBO DRYER SYSTEM	TDS
	BATCH TRAY TYPE DRYER	TDS
	BATCH TYPE TRAY DRYER	TDS
	ATMOSPHERIC TRAY DRYER	TDS
	SEE ALSO DRYERS, DRUM DRYERS, ROTARY DRYERS	-
TREATING TOWERS	SEE TOWERS	-
TUBULAR CLOTH FILTER	CLOTH BAY DUST COLLECTOR	DC
	AUTOMATIC CLOTH DUST COLLECTOR	DC

TUBES	SEE HEAT EXCHANGERS, EVAPORATORS	-
TUMBLERS	SEE MILLS, MIXERS, KNEADERS, BLENDERS	-
TUBULAR REACTOR	HEAT EXCHANGER	HE
	EVAPORATOR	E
	WIPED FILM EVAPORATOR	WFE
	CRYSTALLIZER	CRY
TUMBLE BURNER	ROTARY DRYER	RD
TUMBLE DRYER	ROTARY DRYER	RD
TURBINES	GAS TURBINE	TUR
	SINGLE STAGE STEAM TURBINE CONDENSING TYPE	TUR
	SINGLE STAGE STEAM TURBINE NON-CONDENSING TYPE	-
	SEE ALSO ELECTRICAL GENERATOR UNITS	-
TURBO-COMPRESSORS	SEE TURBINES, COMPRESSORS	-
TURBO DRYING SYSTEM	TURBO DRYER SYSTEM	TDS
	SEE ALSO TRAY DRYING SYSTEMS	-
TOWERS	PACKED TOWER	TW
	COOLING TOWER	TW
	BUBBLE-CAP TRAY TOWER	TW
	TURBO GRID TRAY TOWER	TW
	SIEVE TRAY TOWER	TW
	WASHERS	DC
	SEE ALSO VESSELS, COLUMNS	-
TWO-STAGE ELECTRICAL PRECIPITATOR	LOW-VOLTAGE ELECTRICAL PRECIPITATOR DUST COLLECTOR	DC
	HIGH-VOLTAGE ELECTRICAL PRECIPITATOR DUST COLLECTOR	DC

U

ULTRAFILTRATION SYSTEM	SEE REVERSE OSMOSIS SYSTEM	-
UNLOADERS	SEE CONVEYORS, ELEVATORS	-
UREA REACTOR	CYLINDRICAL PRESSURE VESSEL	VT
	PACKING	TW
	ALSO SEE PACKED COLUMN, VESSEL	-

V

VACUUM CONVEYING SYSTEMS	PNEUMATIC CONVEYING SYSTEM	-
	SEE ALSO COMPRESSORS, FANS, VACUUM PUMPS	-
VACUUM EJECTOR SYSTEMS	EJECTORS	EJ
	STEAM JET REFRIGERATION UNIT	RU
VACUUM PUMPS	MECHANICAL VACUUM PUMP	VP
	WATER-SEALED 20 IN HG VACUUM PUMP	VP
	OIL-SEALED VACUUM PUMP	VP
	MECHANICAL BOOSTER VACUUM PUMP	VP
	SEE ALSO PUMPS, GEAR PUMPS	-
VACUUM SYSTEM	HORIZONTAL VACUUM RECEIVER	HT
	VERTICAL VACUUM RECEIVER	VT
	VACUUM PUMP	VP
	EJECTOR	EJ
	CONDENSER	C
VAPORIZERS	EVAPORATORS	E
	HEAT EXCHANGERS	HE
	WIPED FILM EVAPORATORS	WFE
	FURNACE	FU
	HEATING UNIT	HU
VENT STACK	STACK	STK
VERTICAL TANKS	VACUUM RECEIVER	VT
	CYLINDERICAL VERTICAL TANK	VT
	SPHERIOD	VT
	SPHERE	VT
	ASME CODE CYLINDRICAL VESSEL	VT
	ATMOSPHERIC STORAGE TANK	VT
	CONE ROOF TANK	VT
	OPEN TOP TANK	VT
	LIGHT GAGE TANK	VT
	GAS HOLDER	VT
	JACKETED VACUUM RECEIVER	VT
	JACKETED	VT
	SILO HOPPER	VT
	CONICAL TANK	VT
	CONE ROOF TANK	VT
	STORAGE TANK	VT
	LIFTER TANK	VT
	FLOATING ROOF TANK	VT
	SEE ALSO VESSELS, AGITATED VESSELS	-
VESSELS	VERTICAL TANKS	VT
	HORIZONTAL TANKS	HT
	AGITATED OPEN TANKS	AOT
	AGITATED PRESSURE TANKS	APT
	TRAY TOWERS	TW
	PACKED COLUMNS	TW
	ION EXCHANGERS	IE
	WASHERS	DC
	REACTOR	R
	SPHERIOD	VT

	SPHERE	VT
	THICKENERS	T
	SEE ALSO REACTORS, FIELD ERECTED VESSELS, DRYERS, FILTERS, SCRUBBERS	-
VIBRATING SCREENS	SINGLE DECK VIBRATING SCREEN	VS
	DOUBLE DECK VIBRATING SCREEN	VS
	TRIPLE DECK VIBRATING SCREEN	VS
	SEE ALSO SEPARATORS	-
VIBRATORY SEPARATOR	VIBRATING SCREEN	VS
	VIBRATING CONVEYOR	CO
	ALSO SEE SEPARATOR	-

W

WASHERS	WASHERS	DC
	SEE ALSO SCRUBBERS	-
WASTE RECOVERY/TREATING UNITS	SEE UNDER SPECIFIC ITEM	-
WATER CONDITIONING SYSTEM	WATER TREATMENT SYSTEM	WTS
	ION EXCHANGER	IE
	PACKED COLUMN	TW
	PACKING	TW
	AIR CONDITIONING UNIT	ACU
	AIR DRYER	AD
WATER CONDITIONING/TREATING UNITS	WATER TREATMENT SYSTEMS	WTS
WATER POLLUTION EQUIPMENT	SEE UNDER SPECIFIC ITEM	
WATER SOFTENING SYSTEM	WATER TREATMENT SYSTEM	WTS
	ION EXCHANGER	IE
	PACKING	TW
	PACKED COLUMN	TW
	ALSO SEE PUMP	-
WATER TREATMENT SYSTEMS	DEMINERALIZING SYSTEM	WTS
	SOFTENING TREATMENT SYSTEM	WTS
	FILTERING TREATMENT	WTS
	PUMPING STATION	WTS
	WATER STILL	WTS
	STEAM BOILER	WTS
	PACKAGED BOILER UNIT	WTS
	FIELD ERECTED BOILER UNIT	WTS
	COOLING TOWER SYSTEM	WTS
	SEE ALSO UNDER SPECIFIC ITEM	-
WEAK BASE-STRONG BASE ANIONIC	ION EXCHANGER	IE
WEIGHING SYSTEM	SCALE	S
	CONVEYOR	CO
	FEEDER	FE
WEIGH SCALES	SCALES	S
WETTED-WALL COLUMNS	EVAPORATOR	E
	PACKED COLUMN	TW
	WIPED FILM EVAPORATOR	WFE
WIPED FILM EVAPORATORS	AGITATED THIN FILM EVAPORATOR	WFE
	AGITATED THIN FILM EVAPORATOR - PACKED SYSTEM	WFE
	SEE ALSO EVAPORATORS, DRUM DRYERS, FLAKERS	-

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APPENDIX G

DATA SHEET INDEX

COMMON EQUIPMENT ITEM MODULE NAME	DETERMINING ECONOMIC PARAMETER		DATA SHEET PAGE NO.
	DESCRIPTION	UNITS	
AIR COMPRESSOR	INLET CAPACITY	CUBIC FEET PER MINUTE	AC-1
AIR COMPRESSOR	DRIVER POWER	BRAKE HORSEPOWER	AC-1
AIR CONDITIONING UNIT	CAPACITY	TONS	ACU-1
AIR CONDITIONING UNIT	POWER	HORSEPOWER	ACU-1
AIR DRYER	CAPACITY	CUBIC FEET PER MINUTE	AD-1
AGITATED OPEN TANK	CAPACITY	GALLONS	AOT-1
AGITATED PRESSURE TANK	OVERALL CAPACITY	GALLONS	APT-1
AERATION SYSTEM	CAPACITY	MILLIONS GALLONS/DAY	AS-1
BLENDER	DRIVER POWER	HORSEPOWER	BL-1
BLENDER	CAPACITY	CUBIC FEET	BL-1
CONDENSER	WATER RATE	GALLONS PER MINUTE	C-1
CONVEYOR	LENGTH	FEET	CO-1
CRANE	CAPACITY	TONS	CE-1
APRON CONVEYOR	LENGTH	FEET	CO-3
ROLLER CONVEYOR	LENGTH	FEET	CO-5
PNEUMATIC CONVEYING SYSTEM	OVERALL SYSTEM LENGTH	FEET	CO-7
BUCKET CONVEYOR	LENGTH	FEET	CO-9
CENTRIFUGAL PUMP	FLOWRATE AND HEAD	GALLONS/MINUTE - FEET	CP-1
CRUSHER	FLOWRATE	TONS PER DAY	CR-1
CRYSTALLIZER	FLOWRATE	TONS PER DAY	CRY-1
CRYSTALLIZER	LENGTH	FEET	CRY-1
CENTRIFUGE	DRIVER POWER	HORSEPOWER	CT-1
CENTRIFUGE	BOWL DIAMETER	INCHES	CT-1
CUTTER	DRIVER POWER	HORSEPOWER	CU-1
DRYER	EVAPORATION RATE	POUNDS WATER PER HOUR	D-1
DRYER	HEAT TRANSFER SURFACE	SQUARE FEET	D-1
DUST COLLECTOR	INLET CAPACITY	CUBIC FEET PER MINUTE	DC-1
DRY CAUSTIC PEELER	PRODUCT FLOWRATE	TONS PER HOUR	DCP-1
DRUM DRYER	HEAT TRANSFER SURFACE	SQUARE FEET	DD-1
EVAPORATOR	CAPACITY	GALLONS	E-1
EVAPORATOR	HEAT TRANSFER SURFACE	SQUARE FEET	E-1
ELECTRODIALYSIS	CAPACITY	GALLONS PER MINUTE	ED-1
ELECTRIC GENERATOR	CAPACITY	KILLOWATTS	EG-1
ELECTRIC GENERATOR	CAPACITY	KILLOVOLT-AMPHERES	EG-1
EJECTOR	FLOWRATE	POUNDS AIR PER HOUR	EJ-1
ELEVATOR	LIFT	FEET	EL-1
EQUALIZATION SYSTEM	CAPACITY	MILLIONS GALLONS/DAY	ES-1
EXTRACTOR	CAPACITY	GALLONS PER MINUTE	EX-1
FILTER	DIAMETER	INCHES	F-1
FILTER	FILTRATION AREA	SQUARE FEET	F-1
FEEDER	FLOWRATE	CUBIC FEET PER HOUR	FE-1
FEEDER	SIZE	NUMBER	FE-1
FEEDER	FLOWRATE	POUNDS PER HOUR	FE-1
FLAKER	SURFACE AREA	SQUARE FEET	FL-1
FLOATATION MACHINE	CAPACITY	CUBIC FEET	FM-1
FAN	FLOWRATE	CUBIC FEET PER MINUTE	FN-1
FREEZER	CAPACITY	CUBIC FEET	FR-1
FURNACE	HEAT TRANSFER DUTY	MILLIONS BTU PER HOUR	FU-1
GEAR PUMP	FLOWRATE	GALLONS PER MINUTE	GP-1
HOT AIR BLANCHER	CAPACITY	BTU PER HOUR	HAB-1
HEAT EXCHANGER	HEAT TRANSFER AREA	SQUARE FEET	HE-1
ELECTRICAL HEATER	CAPACITY	KILLOWATTS	HE-3
HOIST	CAPACITY	TONS	HO-1
HORIZONTAL TANK	TOTAL CAPACITY	GALLONS	HT-1
HEATING UNIT	CAPACITY	MILLION BTU PER HOUR	HU-1
INCINERATOR	CAPACITY	POUNDS SOLIDS PER HOUR	I-1
IMPRESSED VOLTAGE SYSTEM	TOTAL CAPACITY	GALLONS	IVS-1
ION EXCHANGER	RESIN VOLUME	CUBIC FEET	IE-1
KNEADER	CAPACITY	GALLONS	K-1
LAGOON SYSTEM	DESIGN FLOW	MILLIONS GALLONS/DAY	LS-1
MILL	PRODUCT CAPACITY	TONS PER DAY	M-1
MILL	DRIVER POWER	HORSEPOWER	M-1
MIXER	PRODUCT CAPACITY	CUBIC FEET	MX-1
MIXER	DRIVER POWER	HORSEPOWER	MX-1
PUMP	DRIVER POWER	HORSEPOWER	P-1
PUMP	FLOWRATE	GALLONS PER MINUTE	P-1
PACKAGING MACHINE	BAGGING RATE	BAGS PER MINUTE	PKG-1
PRESS	AREA	SQUARE FEET	P-1
REACTOR	DIAMETER	FEET	R-1
ROTARY DRYER	HEAT TRANSFER AREA	SQUARE FEET	RD-1
REVERSE OSMOSIS SYSTEM	FLOWRATE	GALLONS PER MINUTE	ROS-1
RAILROAD TANK CAR	CAPACITY	GALLONS	RTC-1
REFRIGERATION UNIT	CAPACITY	TONS	RU-1
SUBMERGED COMBUSTION SYSTEM	CAPACITY	MILLION BTU PER HOUR	SCS-1
SEDIMENTATION SYSTEM	CAPACITY	MILLION GALLONS/DAY	SS-1
STACK	LENGTH	FEET	STK-1
THICKENER	DIAMETER	FEET	T-1
TRICKLING FILTER	CAPACITY	GALLONS PER MINUTE	TF-1
TRAY TOWER	DIAMETER AND NO. TRAYS	FEET	TW-1
COOLING TOWER	FLOWRATE	GALLONS PER MINUTE	TW-3
PACKED COLUMN	DIAMETER AND HEIGHT	FEET	TW-5
ULTRAFILTRATION SYSTEM	CAPACITY	GALLONS PER MINUTE	US-1
VACUUM PUMP	CAPACITY	CUBIC FEET PER MINUTE	VP-1
VIBRATING SCREEN	AREA	SQUARE FEET	VS-1
VERTICAL TANK	CAPACITY	GALLONS	VT-1
WATER TREATMENT SYSTEM	CAPACITY	GALLONS PER MINUTE	WTS-1
STEAM BOILER	CAPACITY	POUNDS STEAM PER HOUR	WTS-3
WATER STILL	CAPACITY	GALLONS PER DAY	WTS-5

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